Ballantine

MODEL 3028A DIGITAL MULTIMETER

INSTRUCTION MANUAL

MODEL 3028A DIGITAL MULTIMETER

Serial No. Prefix 022-

Includes Addendum for Serial No. Prefix 030-

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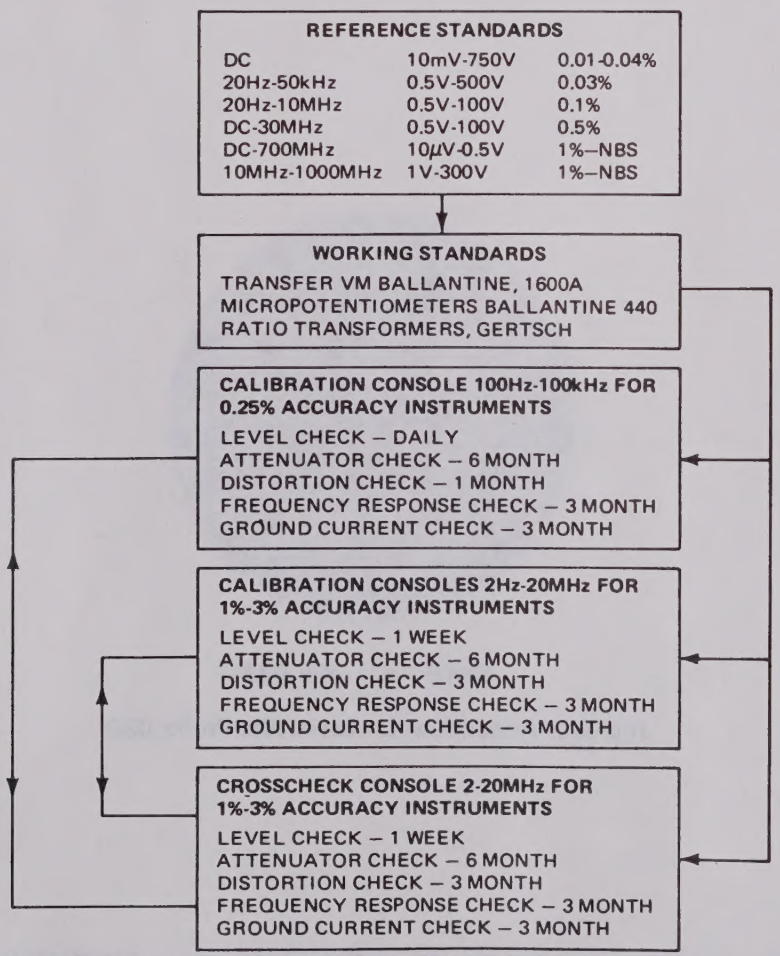
WARRANTY

This Ballantine Laboratories, Inc. product is warranted against defects in materials and workmanship for a period of one year from the date of shipment, except for batteries, electron tubes, vacuum thermocouples, and certain other components, if any, listed in this manual. Ballantine Laboratories, Inc. will, at its option, repair or replace products which prove to be defective during the warranty period provided they are returned to Ballantine Laboratories, Inc. prepaid, and provided the proper preventive maintenance and calibration procedures as listed in this manual are followed. Repairs necessitated by misuse of the product are not covered by this warranty. NO OTHER WARRANTIES ARE EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. BALLANTINE LABORATORIES, INC. IS NOT LIABLE FOR CONSEQUENTIAL DAMAGES.

CERTIFICATION

Ballantine Laboratories, Inc. certifies that this equipment meets all applicable Ballantine specifications at time of shipment as determined by thorough testing and inspection. Ballantine further certifies that its measurements are traceable to the United States National Bureau of Standards. All instruments used in calibrating Ballantine products are standardized by systematic reference to NBS-traceable standards as described in the validation procedures shown below.


REFERENCE STANDARDS
DC 10mV-750V 0.01-0.04%
20Hz-50kHz 0.5V-500V 0.03%
20Hz-10MHz 0.5V-100V 0.1%
DC-30MHz 0.5V-100V 0.5%
DC-700MHz 10μV-0.5V 1%—NBS
10MHz-1000MHz 1V-300V 1%—NBS
WORKING STANDARDS
TRANSFER VM BALLANTINE, 1600A
MICROPOTENTIOMETERS BALLANTINE 440
RATIO TRANSFORMERS, GERTSCH
CALIBRATION CONSOLE 100Hz-100kHz FOR 0.25% ACCURACY INSTRUMENTS
LEVEL CHECK – DAILY
ATTENUATOR CHECK – 6 MONTH
DISTORTION CHECK – 1 MONTH
FREQUENCY RESPONSE CHECK – 3 MONTH
GROUND CURRENT CHECK – 3 MONTH
CALIBRATION CONSOLES 2Hz-20MHz FOR 1%-3% ACCURACY INSTRUMENTS
LEVEL CHECK – 1 WEEK
ATTENUATOR CHECK – 6 MONTH
DISTORTION CHECK – 3 MONTH
FREQUENCY RESPONSE CHECK – 3 MONTH
GROUND CURRENT CHECK – 3 MONTH
CROSSCHECK CONSOLE 2-20MHz FOR 1%-3% ACCURACY INSTRUMENTS
LEVEL CHECK – 1 WEEK
ATTENUATOR CHECK – 6 MONTH
DISTORTION CHECK – 3 MONTH
FREQUENCY RESPONSE CHECK – 3 MONTH
GROUND CURRENT CHECK – 3 MONTH

Ballantine's Quality Assurance program satisfied the requirements of MIL-I-45208

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Figure 1–1. Model 3028A Digital Multimeter

SECTION 1
GENERAL INFORMATION

1–1. INTRODUCTION.

1–2. The Ballantine Model 3028A is a compact, lightweight, portable, digital multimeter (DMM). The instrument incorporates pushbutton selection of seven functions:

Volts	AC (rms responding)
Volts	DC
Amperes	AC (rms responding)
Amperes	DC
Ohms	LO (180 mV full scale)
Ohms	HI (1.8 V full scale)
Test	Display and battery charge

The 3028A features a bright orange, 0.4-inch, LED display of 3½ digits permitting plus or minus 1999 counts. Overrange is indicated by a blinking display. The decimal point is automatically positioned with range selection. Zero drift is prevented with auto-zero circuitry which is particularly useful for low-level and down-scale measurements. Overload protection is provided on all ranges by means of electronic limiters and without the use of fuses. A resettable circuit breaker is used for protecting the current ranges.

1–3. Pushbutton controls permit the selection of five ac and dc voltage ranges, five ac and dc current ranges, five LO ohms ranges, and five HI ohms ranges. The measurement capabilities of the 3028A cover thirty ranges from 100 microvolts to 1200 volts ac and dc, 100 nanoamperes to 1.999 amperes ac and dc, and 100 milliohms to 1.999 megohms LO ohms (<180 mV) and 1 ohm to 19.99 megohms HI ohms (<1.8 V). AC current and voltage measurement capability features rms response and extends from below 15 Hz to beyond 110 kHz. Automatic polarity indication with + or – sign is standard for all dc functions.

1–4. The Model 3028A is fully protected against accidental overvoltage to 1200 volts (dc plus ac rms) on any ac or dc voltage range and 285 volts (dc plus ac rms) on any ohms range will not damage the instrument. The current ranges are protected to 2 amperes by means of a reliable, fast-acting, resettable circuit breaker. Overload recovery is fast enabling measurements to continue with no time loss.

1–5. Front-panel input connectors are convenient universal binding posts which permit use of banana plugs, captive wire leads, and lug-type connections. The three binding posts connect the volts/ohms, current, and common inputs. Binding post spacing is 3/4 inch (190 mm) to enable use of standard connector plugs, shielded connectors and adapters. The use of captive and shielded input connecting cables is a most desirable safety feature when making off-ground and high-voltage measurements. A separate amperes input connector prevents damage to circuits being voltage tested by inadvertent selection of current measuring mode.

1–6. The COMMON input connector is isolated from earth ground and the ac power line mains can operate to ±1200 volts (dc plus peak ac) with reference to earth ground and to the front and rear panels of the DMM. The isolated COMMON input permits safe off-ground voltage and current measurements since it "floats" the instrument circuitry from earth ground.

1–7. A segment test for the three 7-segment LED digits is provided. Simply push both V and mA pushbuttons to test all segments.

1–8. The instrument is enclosed in an attractive rugged case made of shock-resistant, flame-retardant plastic. The case is lined with a heavy conductive metallic coating which provides radio interference shielding. The 3028A is small and light enough to be easily carried. Quality components and reliable design techniques are used throughout to assure high reliability and low power consumption. A reliability analysis using the criteria of MIL-HDBK-217 shows an expected Mean Time Between Failure (MTBF) of 18,650 hours at 25°C.

1–9. SPECIFICATIONS.*

DC VOLTAGE.

Range	Maximum Scale	Resolution
±100 mV	±199.9 mV	100 μV
±1 V	±1.999 V	1 mV
±10 V	±19.99 V	10 mV
±100 V	±199.9 V	100 mV
±1000 V	±1200 V	1 V

Accuracy:
1 year; 15°C to 35°C; ±(0.1% of reading +1 LSD)
24 hours; ±(0.05% of reading + 1 LSD)

Normal Mode Rejection:
Greater than 60 dB at 60 Hz or 50 Hz

Common Mode Rejection (1 kΩ unbalance; COMMON driven):
Greater than 120 dB at dc and 60 Hz or 50 Hz.
Greater than 130 dB at dc and 50 Hz, 60 Hz with internal battery (Option 05)

Maximum Input Voltage: 1200 V (dc plus ac rms sinusoidal)

Input Resistance: 10 megohms on all ranges

Temperature Coefficient:
–10°C to 15°C and 35°C to 55°C
±(0.01% of reading/°C, + 0.005% of Full Scale/°C)

Response Time: ½ second

*All specifications apply from 10% of full scale to full scale.

AC VOLTAGE.

Range	Maximum Scale	Resolution
100 mV	199.9 mV	100 µV
1 V	1.999 V	1 mV
10 V	19.99 V	10 mV
100 V	199.9 V	100 mV
1000 V	1200 V	1 V

Response: RMS responding

Accuracy (sine wave): 1 year, 15°C to 35°C

Percent of Reading – 400 Hz Reference

15 Hz	45 Hz	10 Hz	20 kHz	50 kHz	110 kHz
±(5%+3LSD)	±(0.5%+2LSD)	±(1%+2LSD)	±(2%+2LSD)	±(5%+3LSD)	

Accuracy (complex waveform): For signals having harmonic distortion less than 10% with no single harmonic greater than 5%, add ±(1% of reading + 1 LSD) to sine-wave accuracy from 45 Hz to 10 kHz and ±(1% of reading + 3 LSD) from 15 Hz to 110 kHz.

Temperature Coefficient:
−10°C to 15°C and 35°C to 55°C.
±(0.01% of reading/°C + 0.005% of Full Scale/°C).

Input Impedance: 10 MΩ in parallel with less than 100 pF on all ranges.

Common Mode Rejection (1 kΩ unbalance; COMMON driven):
Greater than 120 dB at dc and 60 dB at 60 Hz or 50 Hz with line operation.
Greater than 130 dB at dc and 70 dB at 60 Hz or 50 Hz with internal battery (Option 05) operation.

DC Blocking Voltage (Normal Mode): 1200 volts dc maximum

Maximum Input Voltage: 1200 V rms sinusoidal on all ranges. Not to exceed 10^3 Volt-Hz.

Response Time: 3 seconds; typically 1 second (within one range).

DC CURRENT.

Range	Max. Scale	Resolution	Input Resistance
± 100 µA	± 1999 µA	100 nA	1000 Ω
± 1 mA	± 1.999 mA	1 µA	100 Ω
± 10 mA	± 19.99 mA	10 µA	10.1 Ω
± 100 mA	± 199.9 mA	100 µA	1.15 Ω
± 1000 mA	± 1999 mA	1 mA	0.25 Ω

Accuracy:
1 year, 15°C to 35°C; ±(0.3% of reading + 1 LSD)

Temperature Coefficient:
−10°C to 15°C and 35°C to 55°C
±(0.015% of reading/°C + 0.005% of Full Scale/°C)

Voltage Burden at Full Scale: 0.25 volt maximum on all ranges except 0.5 FS volt on the 1-ampere range.

Maximum Input: 2 amperes (dc plus ac rms) continuous. Protected by resettable circuit breaker and diode clamps. Limit of 15 A peak.

Response Time: ½ second (within one range).

AC CURRENT.

Range	Max. Scale	Resolution	Input Resistance
100 µA	199.9 µA	100 nA	1000 Ω
1 mA	1.999 mA	1 µA	100 Ω
10 mA	19.99 mA	10 µA	10.1 Ω
100 mA	199.9 mA	100 µA	1.15 Ω
1000 mA	1999 mA	1 mA	0.25 Ω

Response: RMS responding

Accuracy (sine wave): 1 year, 15°C to 35°C

Percent of Reading – 400 Hz Reference.

All Ranges Except 1000 mA

15 Hz	45 Hz	10 kHz	50 kHz	110 kHz
±(5%+4LSD)	±(1%+2LSD)	±(2.5%+2LSD)	±(5%+4LSD)	

1000 mA Range

15 Hz	45 Hz	3 kHz	10 kHz
±(5%+4LSD)	±(1%+2LSD)	±(5%+4LSD)	

Accuracy (complex waveform): For signals having harmonic distortion less than 10% with no single harmonic greater than 5%, add ±(1% of reading + 1 LSD) to sine-wave accuracy from 45 Hz to 10 kHz and ±(1% of reading + 3 LSD) from 15 Hz to 110 kHz.

Temperature Coefficient:
−10°C to 15°C and 35°C to 55°C
±(0.015% of reading/°C + 0.005% of Full Scale/°C)

Voltage Burden at Full Scale: 0.25 volt maximum on all ranges except 0.5 FS volt on the 1000 mA range.

Maximum Input: 2 amperes (dc plus ac rms). Protected by resettable circuit breaker and diode clamps to 15 A peak.

Response Time: 3 seconds (within one range)

RESISTANCE.

Mode	Range	Max. Scale	FS Volts	FS Amps.	Resolution
LOΩ	100 Ω	199.9 Ω	180 mV	1 mA	0.1 Ω
LOΩ	1 kΩ	1.999 kΩ	180 mV	100 µA	1 Ω
LOΩ	10 kΩ	19.99 kΩ	180 mV	10 µA	10 Ω
LOΩ	100 kΩ	199.9 kΩ	180 mV	1 µA	100 Ω
LOΩ	1000 kΩ	1999 kΩ	180 mV	100 pA	1 kΩ
HIΩ	1 kΩ	1.999 kΩ	1.8 V	1 mA	1 Ω
HIΩ	10 kΩ	19.99 kΩ	1.8 V	100 µA	10 Ω
HIΩ	100 kΩ	199.9 kΩ	1.8 V	10 µA	100 Ω
HIΩ	1000 kΩ	1999 kΩ	1.8 V	1 µA	1 kΩ
HIΩ	10 MΩ	19.99 MΩ	1.8 V	100 pA	10 kΩ

Accuracy:
1 year, 15°C to 35°C
All LOΩ ranges, except 1000 kΩ range, and all HIΩ ranges, except 10 MΩ range, ±0.2% of reading + 1 LSD
LOΩ 1000 kΩ range and HIΩ 10 MΩ range, ±0.5% of reading + 1 LSD

Temperature Coefficient:
−10°C to 15°C and 35°C to 50°C ± (0.015% of reading/°C + 0.005% of range/°C), except ±(0.02% of reading/°C + 0.005% FS/°C on LOΩ 1000 kΩ and HIΩ 10 MΩ ranges.

Response Time:
All LOΩ ranges, except 1000 kΩ range, and all HIΩ ranges, except 10 MΩ range, ½ second.
LOΩ 1000 kΩ range and HIΩ 10 MΩ range, 4 seconds.

Maximum Input Voltage (All Ranges) Continuous:
285 volts (dc + ac rms sinusoidal)
Intermittent (10 seconds 20% duty factor), 500 volts (dc + ac peak)
Protected by electronic circuits to 500 volts and 40 mA peak.

ENVIRONMENTAL.

Temperature:
Operating: −10°C to +55°C
Storage: −54°C to +85°C with batteries to 50°C

Humidity:
0 to 90% R.H.
0 to 85% R.H. to 45°C
Usable 0 to 98% R.H. without condensation.
Meets requirements of MIL-T-28800, Class 3

Altitude:
Operating: 0 to 3 km (10,000 feet). Derated linearly above 1 km from rated voltages above 300 volts to half rating at 3 km.
Storage: 0 to 15 km (50,000 feet)

Shock and Vibration: Meets requirements of MIL-T-28800, Class 3, Style D.

Case: Flame-retardant, shock-resistant plastic with full internal metallized shielding and earth-grounded aluminum panels. Handle detents in 12 positions and serves as tilt stand. Meets the requirements of MIL-T-28800, Style D.

Safety: Meets Requirements of MIL-T-28800, Class 3, Style 3.

EMI: Meets requirements of MIL-STD-461A for CS-01, CS-02, CS-06, RS-02, and RS-03 to 400 MHz at 1 V/meter.

GENERAL.

Display:
4 digits and ± polarity sign
7 segment, bright orange
LED 1.1 cm (0.4 inch) character height

Display Test: Three digit, seven-segment test when pushing both V and mA pushbuttons.

Dimensions and Weights:
Height: 63 mm (2-3/8 in.)
Width: 203 mm (8-1/8 in.); with handle 239 mm (9-5/8 in.)
Depth: 222 mm (8-11/16 in.); with handle 298 mm (11-3/4 in.)
Weight: 1.2 kg (2 lb 7 oz)
With batteries 1.85 kg (4 lb 1 oz)
Shipping Weight: 2.94 kg (6.5 lb)

Power: 103 to 128 volts (120 volts nominal), 50 to 400 Hz, 5 watts. Complies with MIL-T-28800, Class 3 power requirements. With Option 06, choice of 100/120/220/240-volt operation is available.

Supplied Accessories:
1 Power Cable, 6½ feet, P/N 33100000A
1 Instruction Manual, P/N 90100935A
1 Probe Test Lead, 4 feet, (red) } P/N 85100620A
1 Probe Test Lead, 4 feet, (black) }

1–10. AVAILABLE ACCESSORIES.

1–11. Table 1–1 lists the accessories available for use with the 3028A.

1–12. OPTIONS.

1–13. Several options are available for the Model 3028A. These options are listed in Table 1–2. Desired options may be specified at time of purchase. Contact your Ballantine representative for additional options which may be available. Table 1–3 defines options incompatibility. Refer to Section 7 for specifications and operating information.

1–14. INSTRUMENT AND MANUAL IDENTIFICATION.

1–15. These Ballantine instruments are identified by a two section serial number. The first three digits section of this number identify the configuration code. This code number appears on the front page of this manual and must coincide with the first three digits of the serial number of your instrument. Addendum sheets supplied with the manual will define technical corrections or differences between your instrument and the unit described in this manual. If applicable, back dating information is located at the end of this manual. This backdating information pertains to instruments with serial number prefixes listed on the title page of this manual.

TABLE 1–1. ACCESSORIES

Model	Description
10800B	40 kV, HV DC Probe
1301B	10 kV, HV AC Probe
10850B	RF Probe, 100 kHz to 700 MHz
10860A	Current Probe, AC, Clamp on to 600A
10801B	Test Lead Kit, 4 probes
10730A	Carrying Case, padded vinyl, 6" x 9" x 12"
10731A	Carrying Case, molded plastic
606	Shunt, AC/DC, 20 Amps (0.01Ω)
10751A	Front Panel Dust Cover
800-09	Rack Mount Kit, left or right (one instrument)
800-10	Rack Mount Kit, side-by-side (two instruments)
12616A	Adapter, Shielded, double banana to BNC female
12617A	Adapter, double banana to BNC female
12249D	Cable, BNC to BNC shielded cable, 4 feet
12250D	Cable, BNC to alligator clips, 4 feet
12251D	Cable, double banana to BNC, 4 feet
12252D	Cable, Shielded, double banana to test probe
—	Battery Replacement Kit P/N 89104221A

TABLE 1–2. OPTIONS

Option	Description	Factory Installed	Field Installed
01	Parallel BCD Printer Output	Yes	No
05	Internal Rechargeable Battery Pack with charger. 16 hour charge, 5 hour operation.	Yes	Yes
06 Series	Universal AC power voltage. IEC compatible multi-tap transformer primary.		
060	86 to 108 V, 48 to 440 Hz (100 V)	Yes	Yes
061	103 to 130 V, 48 to 440 Hz (120 V)	Yes	Yes
062	196 to 245 V, 48 to 440 Hz (220 V)	Yes	Yes
063	208 to 260 V, 48 to 440 Hz (240 V)	Yes	Yes
20	Analog Panel Meter in addition to digital display	Yes	No
21	10 Ampere Current Range	Yes	No
22	Temperature Probe Accessory –40°C to +90°C	Yes	No
23	Temperature Probe Accessory –40°F to 200°F	Yes	No
24	10 mV dc Range with 10 μV resolution	Yes	No
25	AC Power Line Filtering and Surge Voltage Suppression	Yes	Yes
39	102 to 138 volt ac power line, 50 to 400 Hz. Includes battery pack Option 05 and 100 hours burn-in and EMI spec. AC converter only average responding 50 Hz to 50 kHz. Complies with FAA Specification FAA-P-2625.	Yes	No
39A	As above, with ac rms response	Yes	Yes
62	Includes Options 05, 06, 20 and accessory power connector on rear panel for use with UHF Probe Model 10855B which operates only when the DMM is ac-powered.	Yes	No

TABLE 1–3. OPTION INCOMPATIBILITY

Option	01	05	06	20	21	22	23	24	25	39	39A	62
01	–	N	Y	Y	Y	Y	Y	Y	Y	N	N	N
05	N	–	Y	Y	Y	Y	Y	Y	Y	P	P	P
06	Y	Y	–	Y	Y	Y	Y	Y	Y	Y	Y	P
20	Y	Y	Y	–	N	Y	Y	Y	Y	Y	Y	P
21	Y	Y	Y	N	–	Y	Y	Y	Y	N	N	N
22	Y	Y	Y	Y	Y	–	Y	N	Y	N	N	N
23	Y	Y	Y	Y	Y	Y	–	N	Y	N	N	N
24	Y	Y	Y	Y	Y	N	N	–	Y	N	N	N
25	Y	Y	Y	Y	Y	Y	Y	Y	–	Y	Y	Y
39	N	P	Y	Y	N	N	N	N	Y	–	Y	N
39A	N	P	Y	Y	N	N	N	N	Y	Y	–	N
62	N	P	P	P	N	N	N	N	Y	N	N	–

– = Not Applicable N = Not Compatible Y = Compatible P = Included

SECTION 2
INSTALLATION

2–1. INTRODUCTION.

2–2. This section contains information and instructions necessary for the installation and shipping of the instrument. Details are provided for initial inspection, power connection, grounding safety requirements, installation information, and repacking instructions for storage or shipment.

2–3. UNPACKING AND INITIAL INSPECTION.

2–4. Unpacking and initial inspection of the instrument requires only the normal precautions and procedures applicable to the handling of sensitive electronic equipment. The contents of all shipping containers should be checked for included accessories and certified against the packing slip to ascertain that the shipment is complete.

2–5. PERFORMANCE CHECKS.

2–6. This instrument was carefully inspected for mechanical and electrical performance before shipment from the factory. It should be free of physical defects and in perfect electrical order upon receipt. Check the instrument for possible damage incurred in transit and, if necessary, complete the performance checks outlined in paragraphs 5–7 through 5–30. If there is any indication of damage or improper operation, refer to the warranty included in this manual and notify your local Ballantine field engineering representative or the factory.

2–7. POWER REQUIREMENTS.

2–8. The instrument is normally supplied to operate from any ac source of 103 to 128 volts. With Option 06 installed, the tapped primary of the power transformer can be wired to operate from any one of the following ac sources: 86 to 108 volts (100 volts nominal), 103 to 130 volts (120 volts nominal), 196 to 245 volts (220 volts nominal), or 208 to 260 volts (240 volts nominal). All instruments operate over the power frequency range of 48 to 440 Hz. Always verify that the operating line voltage is the same as that specified on the rear panel.

CAUTION

Failure to wire the instrument to match the operating line voltage will damage the instrument and may void the warranty.

2–9. The instrument may also be operated from internal rechargeable nickel cadmium batteries (Options 05 and 39). For battery operation, the line cord is disconnected. Fully charged batteries will operate the instrument for approximately 5 hours. With the line cord connected, the batteries can be fully charged from the line voltage within 14 hours with the POWER switch set to the OFF position. DO NOT charge the batteries for more than 20 continuous hours or the life of the batteries may be shortened. Upon receipt

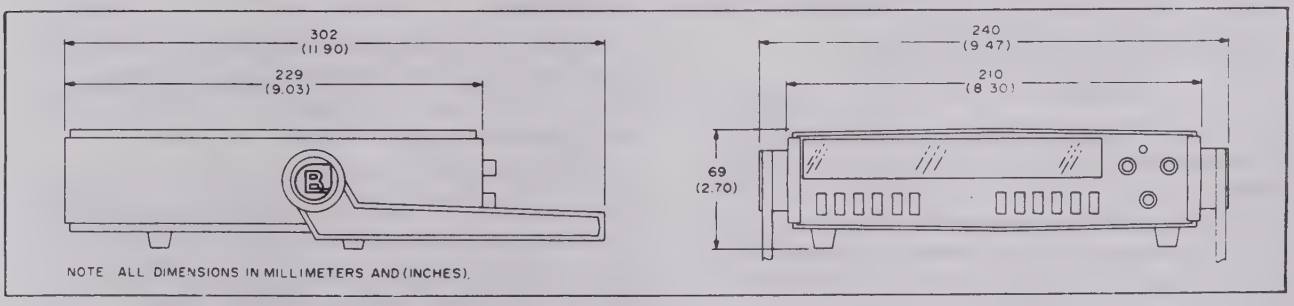


Figure 2–1. Model 3028A, Outline Dimensions

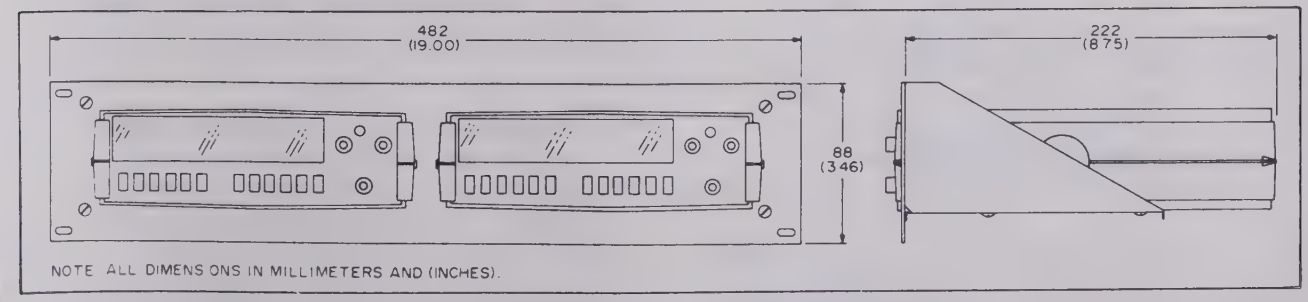


Figure 2–2. Rack Mount Kit, Outline Dimensions

of the instrument, or after extended storage, the batteries should be charged for at least 8 hours prior to use.

CAUTION

When powering the instrument from extremely noisy ac power lines near pumps, elevators, or RFI emitters it is recommended that Option 25 be installed. This option provides power line transient suppression and additional filtering in applications which may otherwise damage the instrument.

2–10. GROUNDING REQUIREMENTS.

2–11. To insure the safety of operating personnel, the U. S. Occupational Safety and Health Act (OSHA) and good engineering practice require that the instrument panel and enclosure be "earth grounded." All Ballantine instruments are provided with a three-conductor power cable assembly which, when plugged into an appropriate power receptacle, grounds the instrument. The offset pin on the male end of the power cable is the ground wire connection to the connector on the rear panel of the instrument.

2–12. To preserve the safety protection feature, when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green lead or terminal on the adapter to "earth ground."

2–13. When using the instrument on internal battery operation, there is no ground return through the power cord. Use caution to avoid electrical shock and consider connecting the instrument cabinet to earth ground through the rear-panel grounding lug or power receptacle grounding pin.

2–14. INSTALLATION AND MOUNTING.

2–15. The instrument is fully solid state and dissipates minimal heat. No special cooling is required. However, the instrument should not be operated where the ambient temperature exceeds 55°C (131°F) or when condensation due to high relative humidity appears anywhere on the instrument. The instrument is shipped ready for use as a portable or bench instrument. Outline dimensions are shown in Figure 2–1.

Note

Before using the instrument, exercise each of the 12 pushbutton switches six or more times. This wiping action cleans switch contacts which may become noisy or intermittent during periods of storage or in contaminating environments.

2–16. The instrument case is provided with a carry handle which also serves as a tilt stand. To change the position of the handle, simply pull both sides of the handle outward from the case to disengage the detent mechanism; then, rotate the handle to the desired position, push the handle back toward the case and rotate slightly until it detents in place. The handle may be removed by firmly, but carefully, pulling both sides of the handle out of the detent mechanisms on the case.

2–17. Rack mounting capability for the instrument is provided by a rack adapter panel. Three 19-inch EIA rack-mount configurations are available. See Figure 2–2 for outline drawings.

2–18. REPACKAGING FOR SHIPMENT.

2–19. If the instrument is to be repackaged for shipment, as a general guide, repackage the instrument as described in the following procedure and shown in Figure 2–3. Use either the original packing material, if available, or material similar to that specified. Proceed as follows:

a. Place the instrument accessories, if any, in a plastic bag and seal the bag.

Note

It is recommended that NiCad batteries be removed from the instrument if extreme environments or storage in excess of twelve months is anticipated.

b. For long distance shipping only, use U. S. Government packaging method IIC and tape a two-unit bag of dessicant (MIL-D-3464) on the rear cover.

c. Place a piece of sturdy cardboard over the front panel for protection. Enclose the instrument in a plastic bag and seal the bag.

d. Wrap the bagged instrument and accessories in 1-inch thick, flexible, cellular plastic-film, cushioning material (PP-B-795) and place in a barrier bag (MIL-B-131). Extract the air from the bag and heat seal.

e. Place the wrapped instrument and accessories into a fiberboard box (PPP-B-636) of suitable size. Fill spaces with rubberized hair or cellular plastic cushioning material. Close box in accordance with container specifications. Seal with sturdy water-resistant tape or with metal straps.

f. Mark container "FRAGILE," "HANDLE WITH CARE," or similar precautionary notice. Affix shipping labels as required or mark according to MIL-STD-129.

Note

If the instrument is to be shipped to Ballantine for calibration or repair, attach a tag to the instrument identifying the owner. Note the problem, the symptoms, and service or repair desired. Record the model and serial number of the instrument. Show the work authorization order as well as the date and method of shipment.

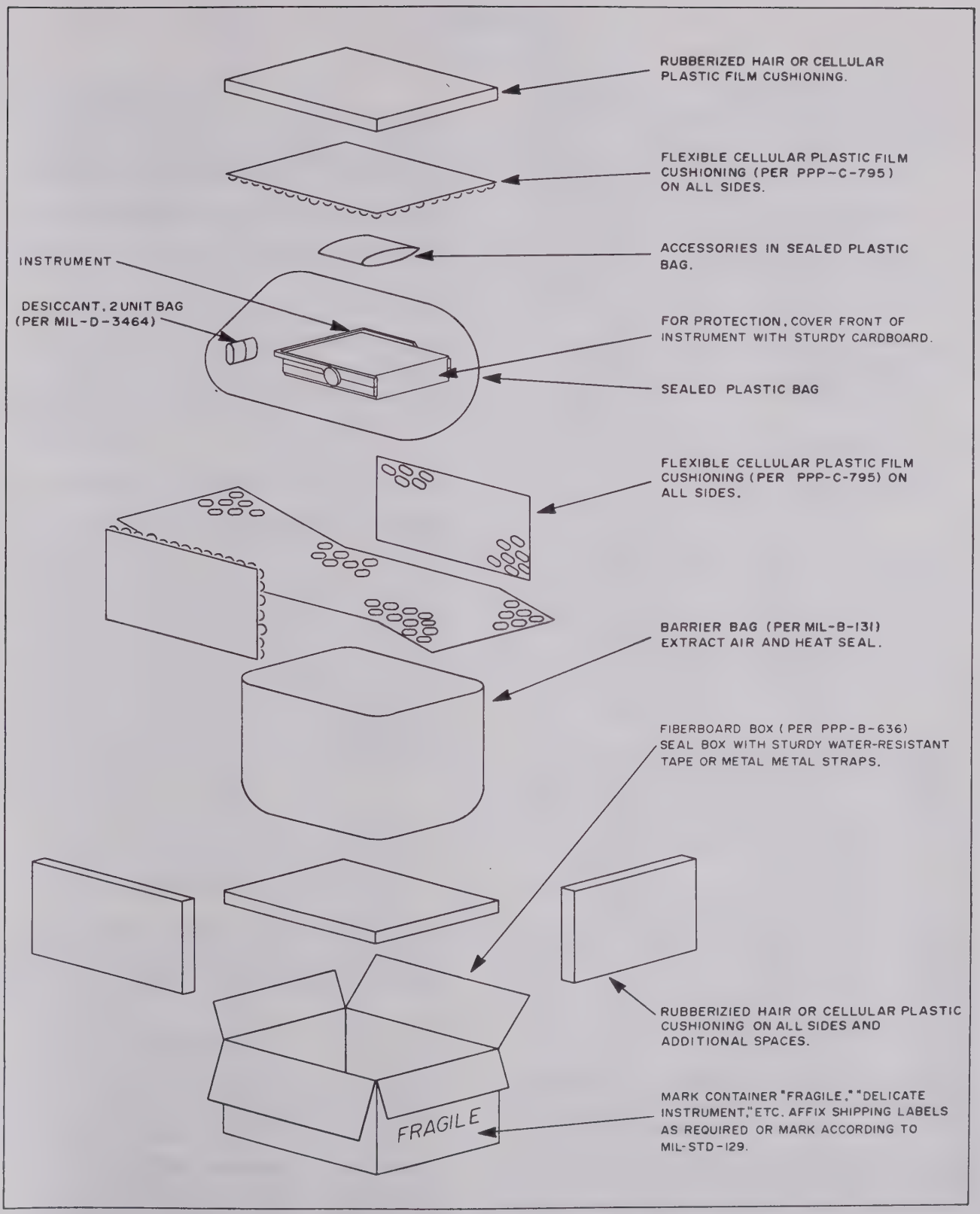

RUBBERIZED HAIR OR CELLULAR PLASTIC FILM CUSHIONING.
FLEXIBLE CELLULAR PLASTIC FILM CUSHIONING (PER PPP-C-795) ON ALL SIDES.
ACCESSORIES IN SEALED PLASTIC BAG.
INSTRUMENT
DESICCANT, 2 UNIT BAG (PER MIL-D-3464)
FOR PROTECTION, COVER FRONT OF INSTRUMENT WITH STURDY CARDBOARD.
SEALED PLASTIC BAG
FLEXIBLE CELLULAR PLASTIC FILM CUSHIONING (PER PPP-C-795) ON ALL SIDES.
BARRIER BAG (PER MIL-B-131) EXTRACT AIR AND HEAT SEAL.
FIBERBOARD BOX (PER PPP-B-636) SEAL BOX WITH STURDY WATER-RESISTANT TAPE OR METAL METAL STRAPS.
RUBBERIZIED HAIR OR CELLULAR PLASTIC CUSHIONING ON ALL SIDES AND ADDITIONAL SPACES.
FRAGILE
MARK CONTAINER "FRAGILE," "DELICATE INSTRUMENT," ETC. AFFIX SHIPPING LABELS AS REQUIRED OR MARK ACCORDING TO MIL-STD-129.

Figure 2–3. Model 3028A, Packing Diagram

NOTES

SECTION 3
OPERATION

3–1. INTRODUCTION.

3–2. This section contains instructions and information required for the operation of the instrument. Included are identification of controls, connectors, options and indicators.

3–3. CONTROLS, INDICATORS, AND CONNECTORS.

3–4. The controls, indicators, and connectors are identified in Figure 3–1 and Table 3–1.

3–5. POWER REQUIREMENTS (AC AND INTERNAL BATTERY).

3–6. See paragraphs 2–7 through 2–9. For grounding and safety earth connections see paragraphs 2–10 through 2–13. Apply ac power of the proper line voltage. Always check rear panel voltage label.

3–7. OPERATING INSTRUCTIONS.

3–8. Turn on power by pushing the POWER pushbutton in to the ON position. The digital display will light up to indicate POWER ON.

3–9. When using internal batteries (Options 05 or 39), check the battery charger condition by removing ac power and simultaneously pushing the 1000 k and 10 M pushbuttons. The display should read above 5 volts or the batteries must be fully charged for 16 hours by applying ac power and turning the power switch to OFF.

3–10. To check the display indicators, simultaneously push the V and mA pushbuttons. All seven segments of the three right-hand numerals must light up.

Note

Additional instructions may be required when options are installed. These instructions are listed later in this section or in Section 7.

3–11. See Table 3–2 and select the desired range and function. Connect the test leads to the corresponding input connectors and observe precautions when measuring hazardous voltages.

3–12. DC MEASUREMENTS.

3–13. DC Voltage.

3–14. See Table 3–2 for dc voltage operation limits.

3–15. Select dc voltage.

a. Depress the V (S3) pushbutton.

b. Check that the AC/DC pushbutton (S2) is out (DC mode).

c. Depress the 1000 pushbutton (S11).

3–16. Connect the input signal to the COMMON and V–Ω input connectors. Select range by first depressing the 1000 (S11) pushbutton and then progressively increasing DMM sensitivity until the display shows three or four significant digits of information.

3–17. DC Voltage Measurement Precautions.

a. Do not exceed 1200 volts dc on any range.

b. Do not float the COMMON input binding post more than 1200 V peak above earth ground.

c. The input resistance of the 3028A is 10 megohms. Measurements from high-source resistances can cause additional measurement errors. This loading error may be calculated by:

$$\%\ \text{loading error} = \frac{100 \times \text{Source Resistance}}{\text{Source Resistance} + 10\ \text{Megohms}}$$

For example, a source resistance of 100,000 ohms will cause a measurement error of 1% of reading.

d. An ac signal superimposed on the dc voltage to be measured may cause reading errors. Such unwanted ac signals are termed normal mode signals since they appear with the signal to be measured. The DMM has a normal mode rejection ratio (NMRR) greater than 60 dB (1000 to 1) at 60 Hz. As an example a 1-volt ac signal in common mode with a 100 mV dc input signal may cause ±1 millivolt of reading error.

e. When the DMM is floated above earth ground an unwanted signal may appear between earth ground and the COMMON input of the DMM. This common mode signal may cause measurement errors. The DMM rejects common mode signals with a rejection ratio (CMRR) of:

120 dB at dc	(1 million to 1)
100 dB to 60 Hz (sinewave)	(100,000 to 1)

This means that a 100-volt peak 60 Hz common mode signal will result in only 1 millivolt of measurement error.

CAUTION

Never exceed 1200 volts dc or ac peak common mode potential.

3–18. Overvoltage Indication. A flashing display indicates overvoltage (overload). Switch to the next higher range until a steady display appears.

3–19. Overrange. The DMM may be used to 200% overrange on all dc ranges and modes up to the limitation of 1200 volts and 2 amperes. A reading of 1000 represents full range and 1999 is considered full scale. The display will flash above 100% overrange when full scale (1999) is exceeded. The

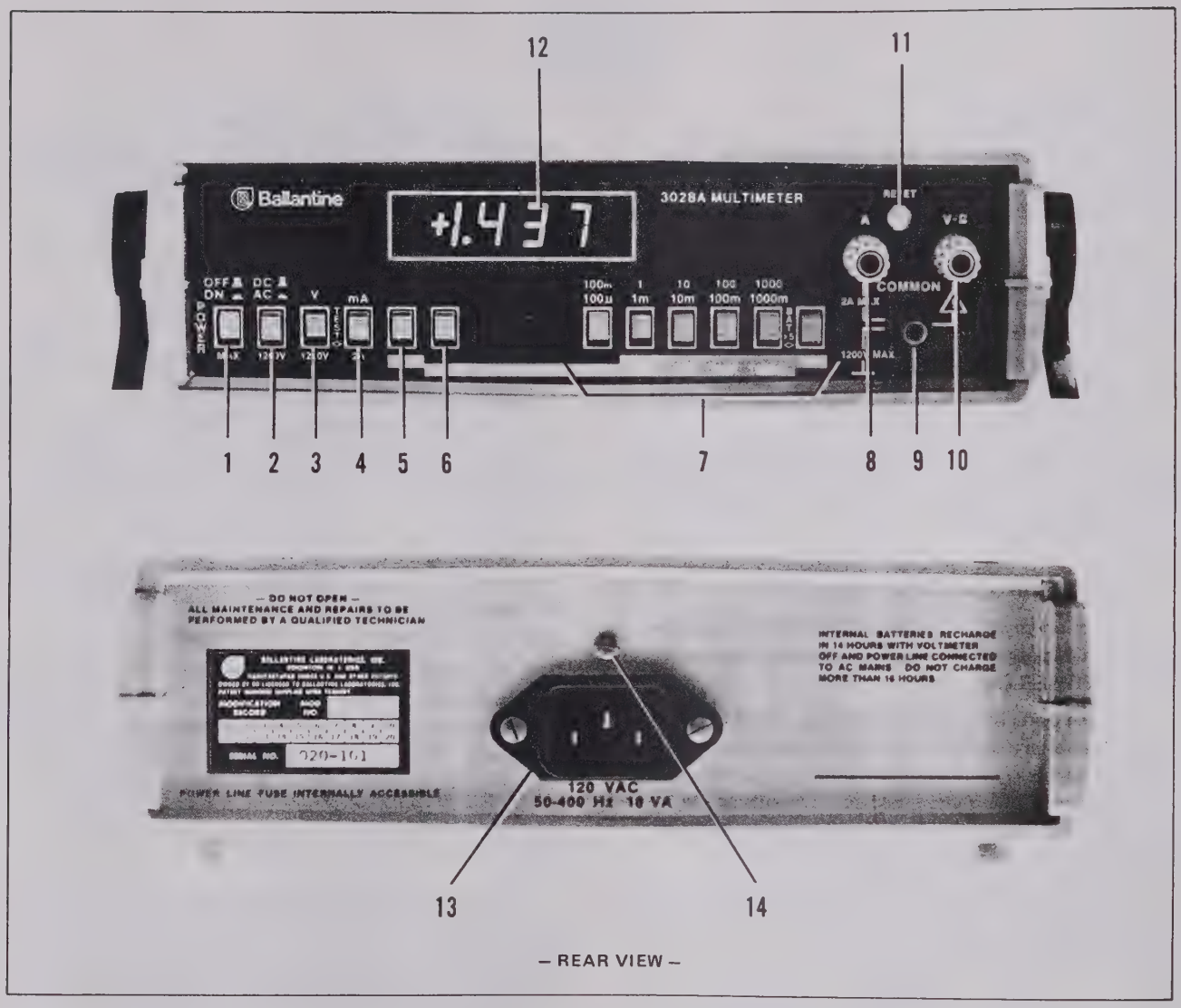


Figure 3–1. Model 3028A, Controls, Indicators, and Connectors

DMM may be used to 2999 with the display flashing and with reduced accuracy.

3–20. Display zero is automatically adjusted. To check zero simply short the V–Ω to the COMMON input connectors with a short strap and the display will read zero plus or minus two counts on all ranges. The display will flash periodically but generally not more than ten times in ten seconds.

3–21. Automatic polarity is a feature of the instrument. Simply apply any dc voltage (negative to COMMON) and read the polarity sign on the display. Turnover error from plus to minus is held to within ±2 counts by the DMM circuitry.

3–22. DC Current.

3–23. See Table 3–2 for dc current operation limits.

3–24. Select dc current.

a. Depress the mA (S4) pushbutton.

b. Check that the AC/DC pushbutton (S2) is out (DC Mode).

c. Depress the 1000 (S11) pushbutton.

3–25. Connect the input signal to the A and COMMON (–) input connector.

3–26. Select range by first depressing the 1000 (S11) pushbutton and then progressively increasing DMM sensitivity until the display shows 3 or 4 significant digits of information.

TABLE 3–1. CONTROLS, INDICATORS, AND CONNECTORS

Index No.	Control, Indicator, Connector	Symbol No.	Function
1	POWER Switch	S1	ON/OFF switch. Charges battery in OFF position.
2	AC/DC Switch	S2	Selects ac or dc volts and mA.
3	V Volts Switch	S3	Selects Volts Mode.
4	mA Amperes Switch	S4	Selects mA Mode.
5	HIΩ Switch	S5	Selects high voltage (1.8V) Ohms Mode.
6	LOΩ Switch	S6	Selects LOΩ voltage (180mV) Ohms Mode.
7	Range Switches	S7, S8, S9 S10, S11, S12	Select one of five voltage and current ranges and one of six ohms ranges.
8	A Connector	J20	Binding post input connector for current mode.
9	COMMON	J30	Binding post input connector for all measuring modes.
10	V–Ω Connector	J10	Binding post input connector for volts and ohms modes.
11	RESET	CB10	Circuit breaker. Push to reset for current overloads >2A.
12	Digital Display	DS750-DS753	Digital readout consisting of 3 seven-segment numerics and 1 plus a polarity indicator.
13	AC Power Receptacle	J50	Power cable receptacle with ac power and "earth" ground.
14	Earth Ground Lug	—	Earth ground connection.

TABLE 3–2. MODEL 3028A OPERATIONAL LISTING

Selected Function	Selected Range	Input Connections	Maximum Input Overload Limits
V DC	100 mV, 1, 10, 100, or 1000 V	V–Ω and COMMON	1200 V dc or ac rms (sinusoidal)
V AC	100 mV, 1, 10, 100, or 1000 V	V–Ω and COMMON	1200 V dc or ac rms (sinusoidal)
mA DC	100 μA, 1, 10, 100, or 1000 mA	A and COMMON	2 A dc or ac rms. Circuit breaker protected to 15 A peak.
mA AC	100 μA, 1, 10, 100, or 1000 mA	A and COMMON	2 A dc or ac rms. Circuit breaker protected to 15 A peak.
HIΩ (> 1.8 V FS)	1 k, 10 k, 100 k, 1000 k, or 10 MΩ	V–Ω and COMMON	285 V dc plus ac rms (sinusoidal) / 500 V dc plus ac rms (sinusoidal)
LOΩ (< 180 mV FS)	100, 1 k, 10 k, 100 k, or 1000 k	V–Ω and COMMON	285 V dc plus ac rms (sinusoidal) / 500 V dc plus ac rms (sinusoidal)
Any	All Ranges	Earth Ground (powerline) and COMMON	1200 V peak

3–27. DC Current Measurement Precautions.

a. Do not exceed 2 amperes on any range. The circuit breaker will protect the mA range on overloads above 2A. To RESET the circuit breaker, allow 10 seconds and push the button above the A binding post input connector.

WARNING

Do not exceed 15 amperes peak input.

b. Do not float the ammeter (dc current meter) COMMON input binding post more than 1200 volts peak above ground.

c. The dc mA input is protected for overvoltage by clipping diodes which clamp at ±200 mV. The protective circuit breaker will trip whenever these diodes clamp and the resultant overload current exceeds 2 amperes.

d. The shunts which meter current in the DMM vary with range. See the specification table in Section 1 for shunt resistance for each range. A measurement error will occur if the source resistance (R_s) is not at least 1000 times greater than the shunt resistance (R_r) of the DMM.

$$\% \text{ error} = \frac{100 \times R_r}{R_s + R_r}$$

For example, on the 1 mA range where the shunt resistance (R_r) is 100 ohms, a source resistance (R_s) of 10,000 ohms will result in a dc mA measuring error of 1% of reading.

e. An ac signal superimposed on the dc current to be measured may cause reading errors. Such unwanted ac signals are termed normal mode signals. The DMM has a normal mode rejection capability in the dc mA mode but ac normal mode current signals should be avoided. When they add excessively to the rms current flowing through the shunt resistors, sufficient current may flow to trip the protective circuit breaker. The peak ac voltages superimposed on the shunt resistors should not exceed 500 millivolts peak-to-peak.

f. The DMM is almost always floated above earth ground when making current measurements. See paragraph 3–17(d) for a description of measurement errors caused by common mode signals. In typical use, the DMM will read ±10 counts of error when 100 volts peak of common mode signal is present. For common mode error calculations on the dc mA ranges always use the most sensitive dc voltage range (100 mV), since the voltage developed across the DMM shunts is 100 millivolts full range.

g. The A to COMMON input connector resistance in the dc mA mode is listed in the specifications. The connector-to-connector resistance is greater than the shunt resistance due to the internal connecting leads. Always consider the connector-to-connector voltage drop when making precision current measurements.

3–28. Overcurrent Indication. A flashing display indicates overload. Switch to the next higher range until a steady display appears.

CAUTION

Do not switch the current range switches when currents exceed 100 mA. This will extend the life of the pushbutton switches.

3–29. The DMM may be used to 200% overrange on all dc mA ranges to 1999 mA (2 amperes). The display will flash above 100% overrange when full scale (1999) is exceeded.

3–30. The display zero is automatically adjusted. To check zero in dc mA mode short the A and COMMON input connectors with a short strap and the display will read 000 plus or minus three counts on all ranges.

3–31. Automatic polarity indication in dc mA mode is a feature of this instrument. Simply apply any dc current (negative to COMMON) and read the polarity sign on the display. Turnover error is held to ±3 counts by the DMM circuitry.

3–32. Currents in excess of 1999 mA may be measured using the Ballantine Model 606 Shunt. This shunt incorporates a 0.01-ohm resistor so that currents to ±20 amperes may be measured using the 100 mV dc range. The 3028A Option 21 is also available and it incorporates a 10-ampere current range.

3–33. AC MEASUREMENTS.

3–34. Response.

3–35. The 3028A Multimeter responds to the rms value of the ac input signal. A unique Ballantine computing ac to dc converter is incorporated in the instrument to permit accurate ac measurements even in the presence of total harmonic distortion of 10%. RMS response and calibration is used to provide a true measure of the power capability of heating value of the input signal.

3–36. The 3028A will provide accurate ac measurements of badly distorted signals. It will respond to the rms value of the input signal regardless of the phase of the input signal components. It is ideal for accurately measuring power line voltages and telephone test voltages, including ringing frequencies and two-tone signals. It is accurate even when total harmonic distortion exceeds 10%, provided no single harmonic exceeds 5%. The input signal should be symmetrical and periodic.

When the input signal is a sine wave with sharp spikes or flattened peaks it is important to check the signal with an oscilloscope to be sure that the crest factor of the signal falls within the broad limits of 1.2 to 1.6. It is usable over the range of 1 to 2.25 and beyond.

$$\text{Crest Factor} = \frac{\text{Signal Peak Volts}}{\text{Signal RMS Volts}}$$

Figure 3–2 shows the voltage relations of a sine wave. It indicates that the crest factor of a sine wave is 1.414.

The 3028A computing ac rms to dc converter has ample dynamic amplitude range for handling all specified crest factors. It is superior in all respects to peak or average responding detectors used in less sophisticated multimeters which will generally read the same as the 3028A on pure sine waves but which will read higher than the 3028A on ac input signals having crest factors < 1.4 and lower than the 3028A for input signals with crest factors > 1.4. The accurate improvement of rms response can provide 4% better accuracy over average responding meters. For full true rms capability, including dc coupling to handle aperiodic and unsymmetrical signals with crest factors to 50, the Ballantine Models 3620A and 3630A are recommended.

3–37. AC Voltage Measurements.

3–38. See paragraph 1–9 for full operating specifications.

3–39. To Select AC Voltage.

a. Depress the V pushbutton and the 1000-volt range pushbutton.

b. Be sure the AC/DC pushbutton is in to select AC.

3–40. Measurement Precautions.

a. Do not exceed 1200 volts rms input on any range.

b. Do not exceed 1200 volts peak between earth ground and the COMMON connector.

c. Take care to minimize test lead capacitive loading of the circuit under test. Use test points which present the lowest possible source impedance. The V–Ω and COMMON input terminals of the multimeter are shunted by 100 pF and 10 megohms. Open test leads may add another 25 pF to 50 pF (or more if leads are twisted or run over a "ground plane").

The loading factor of the shunt capacitance may be determined by the following relationship:

$$X_C \text{ (ohms)} = \frac{1}{2\pi Fc \text{ (Frequency) } F \text{ (Capacity)}}$$

Example for 100 pF shunt capacity at 10 kHz:

$$X_C = \frac{1}{6.28 \times 10{,}000 \times 100 \times 10^{-12}}$$

$$= \frac{1}{6.28 \times 10^{-6}} = 160{,}000\ \Omega \text{ of capacitive reactive loading.}$$

160,00 Ω is only 1.6% of the 10 MΩ shunt resistance but may present a considerable error when it loads an ac test point. In fact, to achieve less than 1% error in multimeter reading accuracy due to capacitive loading, the test point source impedance should be less than one one-hundredth of the combined capacitive loading impedance of the multimeter and test leads. In the foregoing example, the test point impedance must be less than 1600 Ω if the error is to be less than 1% or 160 Ω if less than 0.1%.

The loading effect becomes more important at higher frequencies but is present even at line frequency.

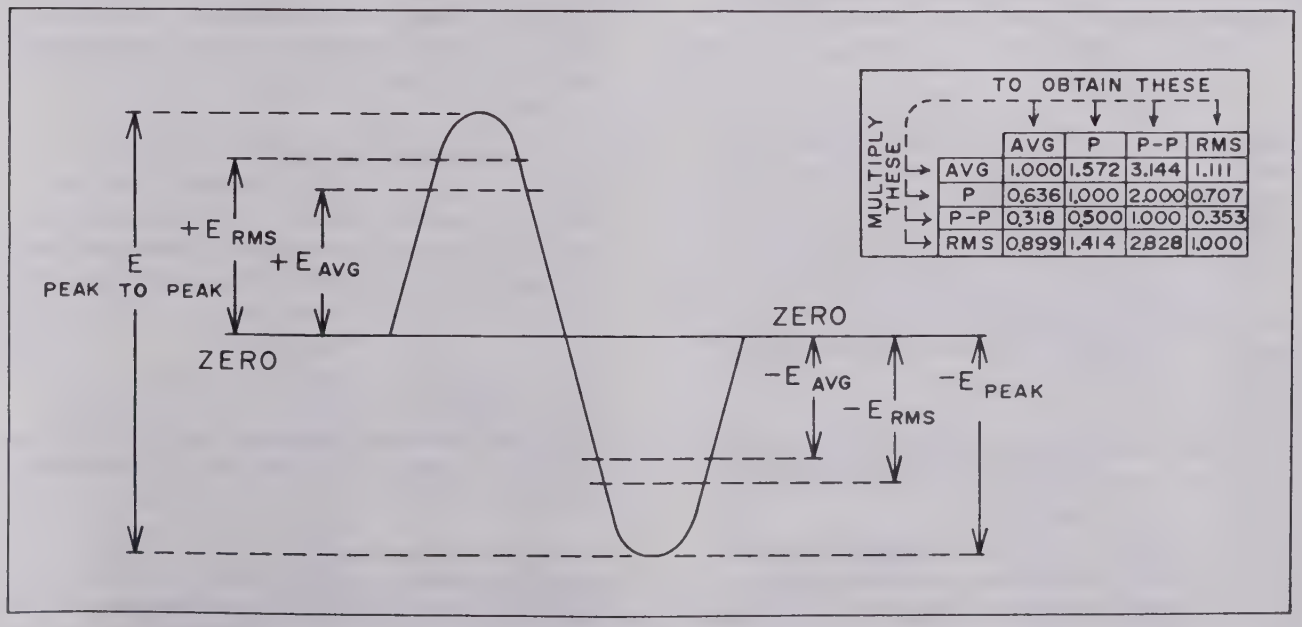


Figure 3–2. Average, RMS, and Peak Voltage Relationships of a Sine Wave

The total input impedance of the DMM may be calculated as follows:

$$Z \text{ input} = \frac{R_{in}}{\sqrt{1 + (2\pi F \times R_{in} \times C_{in})^2}}$$

Input Resistance = R_{in} = 10 Megohms = $10 \times 10^6 \Omega$

Input Shunt Capacitance = C_{in} + C leads $\cong$ 150 pF

Frequency (in Hz) = F

As an example at 60 Hz

$$Z_{in} = 8.72 \text{ Megohms}$$

Measurement error caused by a high source impedance (Z_s) may be calculated as follows:

$$\% \text{ measurement error} = 100 \times \frac{Z_s}{Z_{in} + Z_s}$$

As an example, the error of measurement at 60 Hz from a test point having 100,000 ohms source impedance (Z_s) using the DMM Z_{in} calculated above.

$$\% \text{ error} = 100 \times \frac{100{,}000}{8{,}720{,}000 + 100{,}000} = \frac{100{,}000}{8{,}820{,}000}$$

$$= 1.13\%$$

d. In addition, ac current (I) will flow in the leads causing additional measurement errors. In the above example, at 10 kHz, a 10-volt signal (E) will cause

$$I = \frac{E}{X_C} = \frac{10 \text{ V}}{160{,}000\ \Omega} = 62.5\ \mu A$$

to flow through the test leads and the input circuitry of the DMM.

e. The ac voltage or current to be measured may be "off ground." The multimeter must reject the off ground ac or dc "common mode" voltage. The rejection for common mode voltage is:

> 120 dB at dc	(> 1 million to 1)
> 60 dB at 60 Hz	(> 1000 to 1)

When making ac measurements, use the COMMON input connector as the "low potential" point to system ground (earth). This minimizes the common mode signal errors. Determine if the multimeter reads ac voltages when the test leads are shorted together and tied to the "high" side of the AC signal to be measured. If a reading of some magnitude is then displayed on the multimeter, try to minimize the amplitude of the voltage between case and COMMON. Always limit the common mode voltage to 1200 volts peak.

3–41. Overvoltage Indication. A flashing display indicates overvoltage (overload). Switch to the next higher range until a steady display appears.

3–42. Overrange. The DMM may be used to 100% overrange on the AC mode to the limits of 1200 volts rms sinusoidal (1680 volts peak) and 2 amperes rms sinusoidal. A reading of 1000 represents full range and 1999 is considered full scale. The display will flash above 100% overrange when full scale (1999) is exceeded.

3–43. Frequency range is usable from 15 Hz to beyond 110 kHz for both ac current and ac voltage measurements. The instrument is specified with calibration over the range of 50 Hz to 50 kHz.

3–44. Display zero is automatically adjusted. To check zero simply short the V–Ω to COMMON input connectors with a direct buss wire strap. The display will read zero to 8 counts on all ac ranges. The additional counts beyond zero represent circuit noise seen by the wideband AC to DC converter. This noise adds to the signal as

$$V \text{ display} = \sqrt{(V \text{ input})^2 + (V \text{ noise})^2}$$

Noise contribution to measurement error therefore becomes insignificant for display readings above 0100 (5% of full scale).

An example, 5 digits of DMM noise and 50 digits of signal give a display reading of

$$V \text{ display} = \sqrt{(50)^2 + (5)^2} = \sqrt{2{,}525} = 50.25$$

which will display as 50

3–45. AC Current.

3–46. See Table 3–2 for ac current operation limits.

3–47. To select ac current

a. Depress the mA (S4) pushbutton.

b. Depress the AC/DC pushbutton (S2) in to select AC.

c. Depress the 1000 (S11) pushbutton.

3–48. Connect the input signal to the A and COMMON (LO) input connectors.

3–49. Select range by first depressing the 1000 (S11) pushbutton and then progressively increasing DMM sensitivity until the display shows 3 or 4 significant digits of information.

3–50. AC Current Measurement Precautions.

a. Do not exceed 2 amperes on any range. The circuit breaker will protect the mA range on overloads above 2 A. To RESET the circuit breaker, allow 10 seconds and push the button above the A binding post input connector.

WARNING

Do not exceed 15 amperes peak input.

b. Do not float the ammeter (ac current meter) COMMON input binding post more than 1200 volts peak above ground.

c. The dc mA input is protected for overvoltage by clipping diodes which clamp at ±200 mV. The protective circuit breaker will trip whenever these diodes clamp and the resultant overload current exceeds 2 amperes.

d. The shunt resistors which meter current in the DMM vary with range. See the specification table in Section 1 for shunt resistance for each range. A measurement error will occur if the source resistance (R_s) is not at least 1000 times greater than the shunt resistance (R_r) of the DMM.

$$\% \text{ error} = \frac{100 \times R_r}{R_s + R_r}$$

For example, on the 1 mA range where the shunt resistance (R_r) is 100 ohms, a source resistance (R_s) of 10,000 ohms will result in an ac mA measuring error of 1% of reading.

e. AC currents are often highly distorted yet the Ballantine 3028A improves accuracy since the instrument responds to the ac rms value of the input current. Refer to paragraphs 3–35 and 3–36 and the specifications in Section 1 for additional details.

f. The DMM is almost always floated above earth ground when making current measurements. See paragraph 3–17(d) for a description of measurement errors caused by common mode signals. In typical use, the DMM will read ±10 counts of error when 100 volts peak of common mode signal is present. For common mode error calculations on the ac mA ranges always use the most sensitive ac voltage range (100 mV), since the voltage developed across the DMM shunts is 100 millivolts full range.

g. The A to COMMON input connector resistance in the ac mA mode is listed in the specifications. The connector-to-connector resistance is greater than the shunt resistance due to the internal connecting leads. Always consider the connector-to-connector voltage drop when making precision current measurements.

3–51. Overcurrent Indication. A flashing display indicates overload. Switch to the next higher range until a steady display appears.

CAUTION

Do not switch the current range switches when currents exceed 100 mA. This will extend the life of the pushbutton switches.

3–52. The DMM may be used to 200% overrange on all ac mA ranges to 1999 mA (2 amperes). The display will flash above 100% overrange when full scale (1999) is exceeded.

3–53. The display zero is automatically adjusted. To check zero in ac mA mode short the A and COMMON input connectors with a short strap and the display will read 000 to 008. The residual counts are due to wideband ac circuit noise. See paragraph 3–44 for discussion of its minimal effects on ac measurement accuracy.

3–54. Currents in excess of 1999 mA may be measured using the Ballantine Model 606 Shunt. This shunt incorporates a 0.01-ohm resistor so that currents to ±20 amperes may be measured using the 100 mV ac range. The 3028A Option 21 is also available and it incorporates a 10-ampere current range.

3–55. RESISTANCE MEASUREMENTS.

3–56. **General.** The 3028A measures resistance from 0.1 Ω to 20 MΩ. The display is read directly in ohms, kilohms (kΩ) or megohms (MΩ). The 3028A features both a LO ohms and a HI ohms resistance mode.

3–57. LO ohms may be used for resistance measurements which demand low voltage across and low power dissipation in the resistance to be measured. The LO ohms is advantageous when measuring in-circuit resistances in circuits using semiconductors. Diodes, transistors and other semiconductor junctions are not caused to conduct in the LO ohms mode since the voltage impressed across the unknown resistance is 90 mV at full range and only 180 mV at full scale. See Table 3–2 for LO ohms operating specifications.

3–58. The HI ohms mode is used for checking higher resistances to 20 megohms and for testing semiconductor junctions. The voltage impressed across the unknown resistance is 900 mV at full range and 1.80 V at full scale. This is sufficient to test conduction of diodes and transistors as well as to minimize the effects of leakage. See Table 3–2 for HI ohms operating specifications.

3–59. To select LO ohms

a. Depress the LO Ω pushbutton (S6)

b. Depress the 100 range pushbutton (S7)

3–60. Connect the resistance to be measured across the V–Ω and COMMON input connectors.

3–61. Select range by first depressing the 100 pushbutton (S7) and then progressively increasing the resistance range until the display shows 3 or 4 significant digits of information.

3–62. LO Ohms Measurement Precautions.

a. Do not apply voltage to the input terminals when using LO ohms mode or the reading will be in error.

b. Short the input test leads before making a measurement. Note the zero offset due to test lead and internal resistance of the DMM (typically less than 0.4 ohm). Subtract this "measured zero" reading from the actual measurement to obtain the most precise resistance measurement.

c. Do not exceed 285 V rms (sinusoidal) to the input terminals on the 100 range or more than 500 V rms (sinusoidal) to prevent overload damage.

CAUTION

Take care when making in-circuit resistance measurements which may have high voltages on capacitors or where power line voltage is present.

d. Avoid the LO ohms 1000 k range since its accuracy is affected by leakage in high humidity environments.

e. The LO ohms mode is not applicable to the 10 MΩ range and the display will flash if this range is inadvertently selected.

3–63. To Select HI Ohms

a. Depress the HI ohms pushbutton (S5).

b. Depress the 1 K range pushbutton (S8).

3–64. Connect the resistance to be measured across the V–Ω and COMMON input connectors.

3–65. Select range by first depressing the 1 K pushbutton (S8) and then progressively increasing the resistance range until the display shows 3 or 4 digits of significant information.

Note

The 100 range (S7) is not operative in the HIΩ mode and the display will flash should this range be inadvertently selected.

3–66. HI Ohms Measurement Precautions.

a. Do not apply voltage to the input terminals when using HI ohms mode or the reading will be in error.

b. Short the input test leads before making a measurement. Note that zero offset due to test lead and internal resistance of the DMM (typically less than 0.4 ohm). Subtract this "measured zero" reading from the actual measurement to obtain the most precise resistance measurement.

c. Do not exceed 285 V rms (sinusoidal) to the input terminals on the 100 range or more than 500 V rms (sinusoidal) to prevent overload damage.

CAUTION

Take care when making in-circuit resistance measurements which may have high voltages on capacitors or where power line voltage is present.

3–67. Overrange Indication. A flashing display indicates too high resistance for the range selected. Switch to next lower range until a steady display appears.

3–68. The DMM may be used to 200% overrange on all ohms ranges to a limit of 2 megohms in LO ohms and 20 megohms in the HI ohms mode. The display will flash above 100% overrange when full scale (1999) is exceeded.

3–69. The display zero is automatically adjusted. To check zero short the test leads connected to the V–Ω and COMMON input connectors together. Note the reading which should typically be limited to 001 to 010 by keeping the test leads short and the low resistance. Note the "actual zero" and subtract this offset from the actual reading to obtain the most precise resistance measurements.

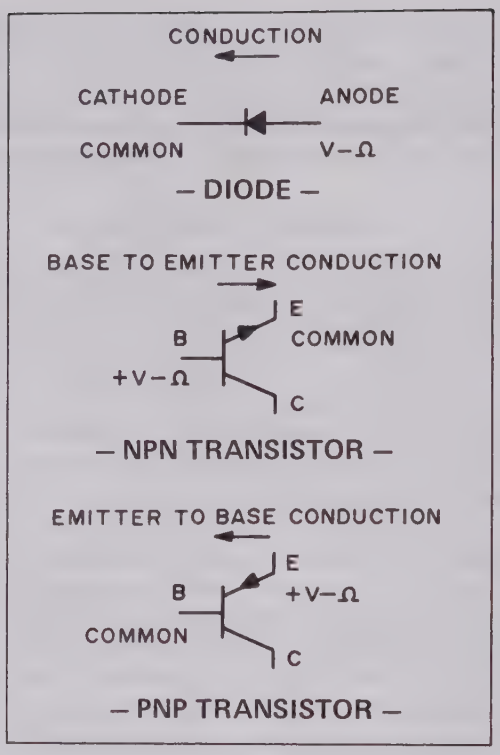


Figure 3–3. Transistor and Diode Testing

3–70. Testing Semiconductor Junctions.

3–71. The 3028A may be used to test transistors, diodes, and integrated circuits to determine the condition of the semiconductor junction. The V–Ω input connector is positive in respect to the COMMON connector and connections should be made as shown in Figure 3–3 to cause forward conduction.

3–72. The voltage applied to semiconductor junctions must be sufficient to cause conduction in the forward direction. The HI Ω mode provides a voltage to 1.8 volts and a maximum current of 1 mA (1 kΩ range) which is sufficient to cause forward conduction.

Note

Tests on silicon diodes and power transistors should be performed using the HIΩ 1k range to permit maximum current to flow. Higher resistance ranges generally have too low a measuring current to properly test forward conduction of the junction.

3–73. To test a transistor or diode, first identify the leads as given on the schematic or the manufacturer's data sheet. To determine the condition of a transistor, a measurement of base-emitter and base-collector junctions is required. See Table 3–3 for test conditions for silicon NPN and PNP transistors.

TABLE 3–3. TEST CONDITIONS FOR SILICON TRANSISTORS

Transistor	Connector		DMM		Normal Indication	Faulty Indication
	COMMON (–)	V–Ω (+)	Function	Range		
NPN	Emitter	Base	HIΩ	1K	≈700 Ω	>1000 Ω <400 Ω
NPN	Base	Emitter	HIΩ	10M	>20 MΩ (flashing)	<20 MΩ
NPN	Base	Collector	HIΩ	10M	>20 MΩ (flashing)	<20 MΩ
NPN	Collector	Base	HIΩ	1K	≈700 Ω	>1000 Ω <400 Ω
PNP	Base	Emitter	HIΩ	1K	≈700 Ω	>1000 Ω <200 Ω
PNP	Emitter	Base	HIΩ	10M	>20 MΩ (flashing)	<20 MΩ
PNP	Collector	Base	HIΩ	10M	>20 MΩ (flashing)	<20 MΩ
PNP	Base	Collector	HIΩ	1K	≈700 Ω	>1000 Ω <400 Ω

3–74. In-Circuit Measurement of Resistance.

3–75. In-circuit resistances may be measured with the Model 3028A using the LOΩ mode. LOΩ has a maximum voltage of 180 mV full scale which is generally insufficient to obtain conduction in transistor and semiconductor diode junctions.

3–76. In-Circuit Resistance Measurement Precautions.

a. Always turn off all power on the circuit under test and wait sufficient time to discharge all capacitors which may retain a voltage which can damage the ohmmeter (>285 volts rms) or cause measurement errors.

b. Check the schematic of the circuit under test to be certain that the component to be measured is not shunted by others which will cause apparent measurement errors and confusion.

c. When checking sensitive components such as detector diode junctions, minimize ohmmeter measuring current by selecting a higher resistance range (such as 10k where maximum measuring current is 180 microamperes). Since measuring current is directly proportional to measuring voltage, it is recommended that downscale (<300) measurements be used to minimize ohmmeter power impressed on the device under test.

As an added precaution, short the ohmmeter test leads BEFORE and while initially applying them to the sensitive circuit component under test so that the initial ohmmeter measurement potential is zero. Then release the short and make the resistance measurement. Use of this technique never lets the measuring potential exceed the voltage at which the final resistance measurement is made.

3–77. ACCESSORIES – OPTIONAL.

3–78. RF Probe Model 10850B.

3–79. The Ballantine 10850B probe is a peak detector probe which provides voltage measurement capabilities for sinewaves to beyond 700 MHz. It is a peak detector probe using a semiconductor diode. Maximum signal is 30 V ac and a blocking capacitor will hold off dc to 200 volts maximum.

CAUTION

Never exceed these maximum voltage ratings.

3–80. The 10850B is usable from 50 kHz to beyond 700 MHz. It can be calibrated at any frequency with the adjustment provided in the compensating box at the end of the cable. Normal use provides broadband flatness within

±0.5 dB to 200 MHz, ±1 dB at 270 MHz, and ±3 dB at 470 MHz. Do not use for signals less than 10 mV or below 50 kHz since the detector time constant is too short. The probe may be used as an AM detector if modulation frequencies are in the 50 Hz to 20 kHz range.

3–81. The 10850B is supplied with a ground lead as well as a BNC tip adapter. The ground lead inductance will cause substantial measurement accuracy errors above 10 MHz and the BNC adapter must always be used when calibrating or measuring higher frequency signals.

3–82. The probe may be calibrated by adjusting the trimmer potentiometer in the termination housing on the 1-volt or 10-volt ranges from any known precision ac source within its frequency range. Always use the 10850B RF probe on the 100 mV, 1 V, and 10 V ranges of the 3028A DMM. The calibrating reference frequency is 10 MHz although any frequency from 1 MHz to 200 MHz may be used as the set point.

3–83. High Voltage DC Probe Model 10800B.*

3–84. The Ballantine 10800B high voltage probe is used to divide high dc voltages so they may be measured by the DMM. Division ratio is 1000 to 1 and is adjustable by ±10% to permit precise calibration of the division ratio of the probe to the multimeter.

3–85. Maximum probe voltage rating is ±40 kV dc. At no time should the 40 kV peak rating be exceeded.

WARNING

ALWAYS CONNECT THE GROUND LEAD TO THE CIRCUIT UNDER TEST BEFORE CONNECTING THE HV PROBE. FAILURE TO OBSERVE THIS PRECAUTION WILL APPLY FULL HIGH VOLTAGE TO THE INSTRUMENT AND MAY NOT ONLY RESULT IN INSTRUMENT DAMAGE BUT MAY CAUSE A SERIOUS PERSONNEL HAZARD. ALWAYS CONNECT THE GROUND LEAD FIRST AND PERMANENTLY WHEN USING THE HIGH VOLTAGE PROBE. HANDLE THE PROBE ONLY AT ITS BLACK HANDLE AND AVOID CONTACT WITH THE FLASH GUARD AND TIP AREA.

3–86. The accuracy of the probe is ±1% plus the accuracy of the DMM. A voltage coefficient of 0.0002% (2 ppm) per volt to 10 kV, 0.0003% (3 ppm) per volt to 20 kV, and 0.0005% (5 ppm) per volt to 40 kV is additionally applicable. The probe is calibrated at 1 kV or 10 kV dc with the potentiometer located in the terminating box.

3–87. The probe ground is always connected to the COMMON input connector. Set the DMM to DC and V. Use the 1 V, 10 V and 100 V ranges of the multimeter and read directly to 1.999 kV on the 1 V ranges, 19.99 kV on the 10 V range and 40.00 kV on the 100 V range.

3–88. High Voltage AC Probe Model 1301B.

3–89. The 1301B High Voltage AC Attenuator Probe is used for measurements up to 10,000 volts rms (sinusoidal); or 14 kV peak. The probe is a capacitive divider with a division ratio of 10,000 to 1 (80 dB). Although the 1301B has a usable frequency response from 10 Hz to 6 MHz it is usable with the 3028A ac volts measuring mode to provide high voltage measurements from <40 Hz to beyond 100 kHz.

3–90. To use the 1301B Probe, switch to AC and V. Set range to 100 mV or 1 volt to read 1.999 kV or 10 kV rms, respectively.

WARNING

ALWAYS CONNECT THE GROUND LEAD TO THE CIRCUIT UNDER TEST BEFORE CONNECTING THE HV PROBE. FAILURE TO OBSERVE THIS PRECAUTION WILL APPLY FULL HIGH VOLTAGE TO THE INSTRUMENT AND MAY NOT ONLY RESULT IN INSTRUMENT DAMAGE BUT MAY CAUSE A SERIOUS PERSONNEL HAZARD. ALWAYS CONNECT THE GROUND LEAD FIRST AND PERMANENTLY WHEN USING THE HIGH VOLTAGE PROBE. HANDLE THE PROBE ONLY AT ITS HANDLE AND AVOID CONTACT WITH THE FLASH GUARD AND TIP AREA.

3–91. To calibrate the 1301B probe, simply unscrew the probe tip to provide access to the calibration adjustment screw. Connect the probe to the V–Ω and COMMON connectors and set the DMM to AC and V. Set range to 100 mV. Apply 1 kV at 1 kHz to the probe from a voltage calibrator such as the Ballantine 421A. Adjust the probe calibration until the 3028A reads 1.000 ±3 digits.

*For operator safety, when using high-voltage probes such as the 10800B and 1301B, permanently connect a 3.3 MΩ, 1/2 W resistor (P/N 12129340A) from the power line to earth ground, and a 47 MΩ, 1 W resistor (P/N 12129350A) from COMMON to earth ground.

SECTION 4
THEORY OF OPERATION

4–1. INTRODUCTION.

4–2. This section of the manual contains a description of the circuitry used in the 3028A. Figure 4–1 is a simplified block diagram of the instrument. Basically, the diagram can be broken down into eight functional areas. These are input voltage divider, current shunts, ohms converter, active filter, ac (volts to mA) converter circuit, dc analog-to-digital converter, digital display section, and the power supply.

4–3. CIRCUIT DESCRIPTION.

4–4. A complete schematic is shown in Figure 6–1. Refer to this schematic diagram throughout the following circuit description.

4–5. Input Voltage Divider (Reference Designator 100 Series).

4–6. A ten-megohm series connected resistor set is tapped to provide division ratios of 1, 100 and 1000 to 1. Resistor R100 and trimmer potentiometer R101 set the 100 to 1 tap. Resistors R102 and R103 set the 1000 to 1 tap. Resistor R104 is the basic high-stability calibration resistor in the input attenuator and is the resistive reference for the ohmmeter. The 100 mV and 1 V ranges use the 1 to 1 tap. The 10- and 100-volt ranges use the 100 to 1 tap and the 1000-volt range uses the 1000 to 1 tap.

4–7. Trimmer capacitors are connected across the input voltage divider to maintain a constant attenuation ratio over the frequency band when the input voltage divider is used for ac voltages. High frequency response compensation may be adjusted during calibration with trimmer capacitor C103 for the 1000 to 1 range and with C110 for the 100 to 1 range and C107 when attenuator components are replaced.

4–8. Current Shunts (Reference Designator 200 Series).

4–9. Current shunts consist of three two-terminal and two four-terminal stable noninductive wirewound resistors enclosed in RN200, a dual in-line resistor package. These series-connected resistors are selected depending on the ac or dc current range selected. Resistances of 1000, 100, 10, 1 and 0.1 ohm correspond to the 100 μA, 1 mA, 10 mA, 100 mA and 1000 mA ranges, respectively. The four-terminal resistor ensures accurate current measurements with variations in lead resistance and components. The input COMMON connections are completed through the resistor network to the analog circuit ground of the DMM.

4–10. The voltage required across any shunt for a display reading of 1000 is 100 mV and the maximum voltage is 200 mV at full scale. The shunts are protected against overvoltage by power diodes CR200 through CR203. Current overload protection above 2 A is provided by quick acting thermal circuit breaker CB10.

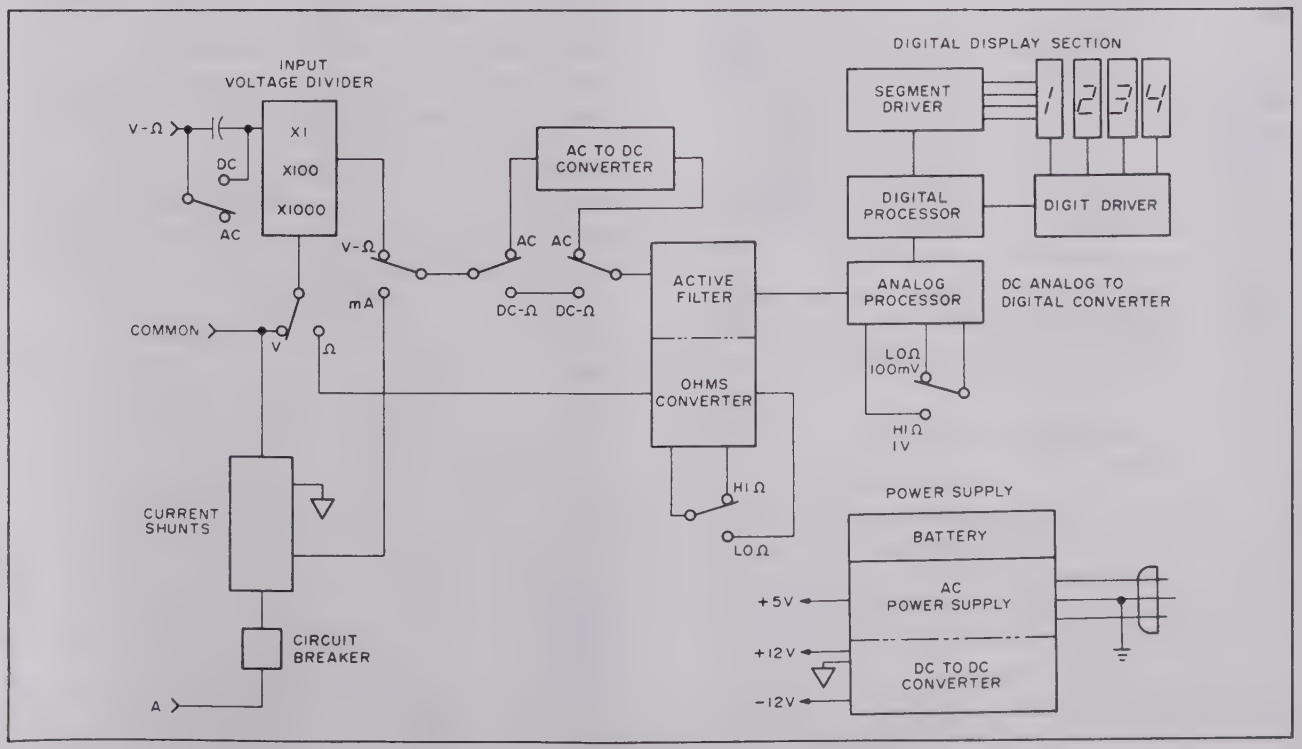


Figure 4–1. Model 3028A, Block Diagram

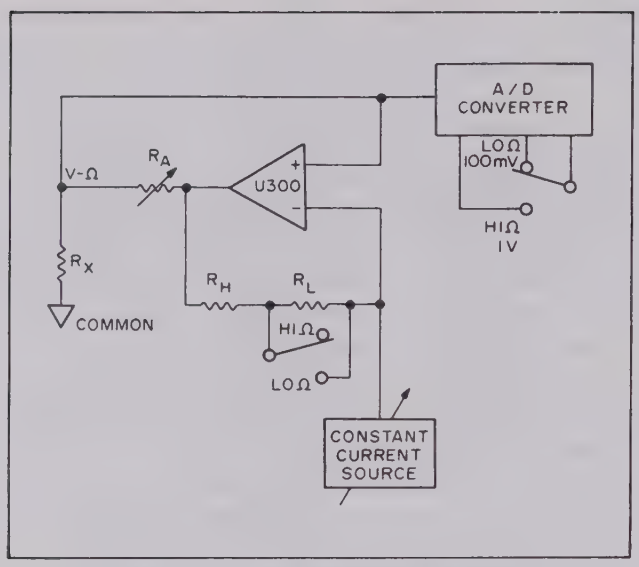


Figure 4–2. Simplified Ohms Converter

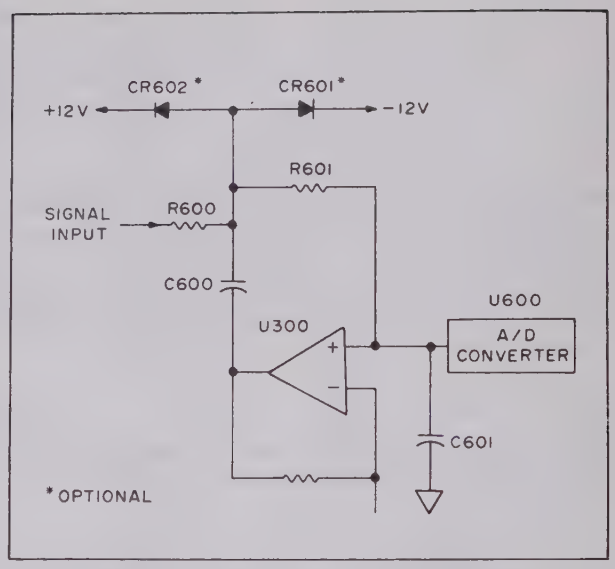


Figure 4–3. Active Filter, Simplified Diagram

4–11. Ohms Converter (Reference Designator 300 Series).

4–12. The ohms converter provides a constant current through the unknown resistance to be measured (R_X). This current creates a voltage drop across R_X which is then measured by the dc analog voltage to digital converter. See Figure 4–2 for a simplified diagram.

4–13. FET input operational amplifier U300 bootstraps the current source comprised of Q300, Q301 and Q302. Q301 is diode-connected to temperature compensate Q300 while Q302 acts as the voltage reference. Constant current level is set by R303 and R304 in the emitter return of Q300. R_A is the input voltage divider, resistors R100 through R104, switched for ohmmeter ranging. With the non-inverting input of U300 connected to the junction of R_A and R_X, current is caused to flow through R_A and R_X. The inverting input of U300 is used to stabilize the voltage and gain across U300 by making the constant current flow through feedback resistors R_H and R_L.

4–14. For a given range and HIΩ or LOΩ mode a constant voltage is maintained across R_A. If R_X is within the range selected, the voltage developed will be directly proportional to R_X.

4–15. The constant voltage across R_A is maintained as indicated in Table 4–1.

4–16. The HIΩ mode requires 1.8 V across R_X at a full scale reading of 1999. In this mode R_H plus R_L are 10 kΩ and provide negative feedback across U300. The sensitivity of the dc analog voltage to digital converter is now set to 1 V. The HIΩ mode is not operative on the 100 range.

4–17. Ohms overload protection is provided by the current limiting of the 7-watt, 10 kΩ input voltage divider resistor R104 and Zener diodes CR300 and CR301 which limit the voltage excursion at the output of U300 to ± 10 volts. The dc analog voltage to digital converter is protected against overvoltage by R600, R601, and limiting diodes within U300.

4–18. The dc analog voltage to digital converter has its basic sensitivity increased for a full scale reading of 1999 whenever 1800 is applied in either ohms mode. Gain switching is accomplished by S5F and S6C which insert a 28.7 kΩ resistor from RN600 into the feedback chain. This minimizes the maximum LOΩ measuring voltage to 180 mV.

4–19. Active Filter.

4–20. The active filter is a two-pole, low-pass filter which rejects ac signals and passes only dc voltages to the dc analog voltage to digital converter. A cutoff frequency (–3 dB) of 8 Hz and a rejection ratio of 38 dB at 60 Hz are provided by this filter. The active filter also prevents overloading of the converter input when large ac voltages are superimposed on the dc voltage to be measured.

TABLE 4–1.

Range	Mode	R_A	Volts across R_A
100	LOΩ	10 kΩ	10
1 kΩ	LOΩ	10 kΩ	1
10 kΩ	LOΩ	100 kΩ	1
100 kΩ	LOΩ	10 MΩ	10
1000 kΩ	LOΩ	10 MΩ	1
1 kΩ	HIΩ	10 kΩ	10
10 kΩ	HIΩ	100 kΩ	10
100 kΩ	HIΩ	100 kΩ	1
1000 kΩ	HIΩ	10 MΩ	10
1 MΩ	HIΩ	10 MΩ	1

4–21. Operational amplifier U300 is used for the active filter as well as the ohms converter. Its noninverting input senses the signal at the input of the converter and feeds it through C600 to the junction of R600 and R601. In effect, it multiplies the resistance of R601 at high frequencies and therefore provides a larger effective time constant for the low-pass filter comprised of R600, R601 and C601. See Figure 4–3 for a simplified diagram of the active filter. Optional diodes CR601 and CR602 provide high peak overload protection for U300 and U600 by limiting at ± 12 V.

4–22. AC to DC Converter (Reference Designator 400 Series).

4–23. The ac to dc converter takes the ac input signal from the input voltage divider or the current shunts and converts it into a dc voltage. This dc voltage is then measured by the dc analog voltage to digital converter. The ac to dc converter is a wideband circuit operating from <15 Hz to beyond 250 kHz and over a dynamic range of 100 μV to beyond 2 volts rms. See Figure 4–4 for a simplified diagram of the ac converter.

4–24. The input to the ac converter consists of field effect transistor Q400. This dual gate MOSFET is connected with PNP Q401 to provide high input impedance and low output impedance. It has internal diode protection for input overloads. Resistor R400 is the voltage dropping resistor which limits the FET input current to avoid damage during overloads.

4–25. The input FET follower (Q400) and transistor (Q401) drive the noninverting input of operational amplifier U400. Diodes CR400 and CR401 protect the input of U400 from overloads. Feedback from the output of U400 to its inverting input causes the operational amplifier output to follow the input signal from FET follower Q400. This results in a current flow from ground through R408 plus R409 which is equal to $E_{in}/(R408 + R409)$. Diodes CR402 and CR403 conduct on alternate cycles of the input ac waveform. Therefore, one-half the average current flows through R406. The ac to dc converter is an operational full wave rectifier and the voltage at the junction of CR403 and R406 is sent through low pass filter R411 and C410 for measurement by the dc analog voltage to digital converter. The detector responds to the average of the ac signal input and is calibrated in rms of a sine wave. U500 is a high-performance operational amplifier which in conjunction with CR500 and C501 forms a positive peak detector. The peak value of the input signal is stored in C501 and added to the output from the average responding detector through R504. R411 and R504 are chosen to give optimum rms response at a crest factor of 1.41 ± 20%.

4–26. The input to the ac converter is either 200 mV or 2 V full scale. The circuit is designed to operate over this two decade dynamic range without changing gain. AC conversion gain is adjusted by R409. R506 sets downscale linearity. Crest factor ratio is set by R411 and R504.

4–27. DC Analog Voltage to Digital Converter (Reference Designator 600 Series).

4 28. The dc input voltage is coupled to the analog processor U600 via the precision input voltage divider and a two-pole active low-pass filter. The input voltage to the processor is limited by internal voltage limiters and protective diodes in U300. Ranging resistors in the input voltage divider are selected by the front panel RANGE switches to provide a 100-millivolt voltage for the 100 mV and 10 volt ranges and 1 volt for all other ranges.

4–29. The monolithic analog processor contains a bipolar comparator, a bipolar integrating amplifier, two MOSFET input amplifiers, several analog switches and the necessary level shifting drivers to allow the analog and digital processors to be directly interfaced.

4–30. The precision voltage reference Q601 is temperature compensated and supplied by constant current source Q600.

4–31. The feedback resistors which set gain in the analog processor are housed in resistor network RN600 for optimum temperature stability. R604 provides coarse calibration adjustment over the voltage limits reference Q601. R608 is the 100 mV range calibration adjust. R607 serves as the 1 V calibration adjust.

4–32. Input offset current compensation is provided by shifting the reference ground level at the input of the analog

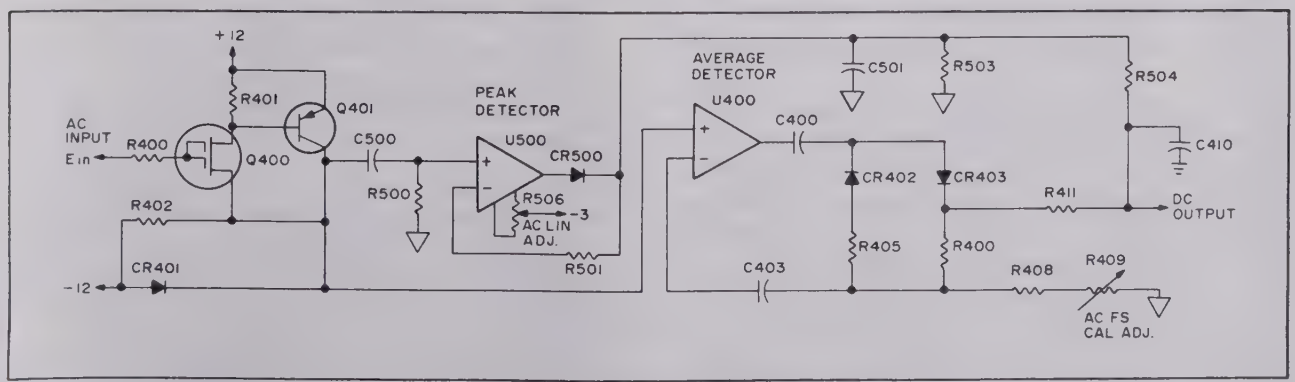


Figure 4–4. AC Converter, Simplified Diagram

processor U600. R605 provides offset compensation for a compromise of optimum polarity turnover and display zero adjust.

4–33. A measurement cycle consists of two phases: the measure interval and the auto-zero interval. In the measure interval, a conversion technique balances the charge supplied by a current proportional to the input voltage. The accumulation of quantized charges is measured and read as a digital number in BCD format. The units of quantized charge are provided through pulse width modulation of a reference current.

4–34. The auto-zero interval allows the effect of offset, temperatures, and drift to be impressed on the auto-zero storage voltage, which is maintained as a reference by the capacitor C602. Therefore, during the succeeding measure interval, these effects will be balanced out. The input of the buffer amplifier is grounded during this interval.

4–35. Digital Display Circuits (Reference Designator 700 Series).

4–36. The digital processor U700 derives its inputs from analog processor U600 and provides segment control and digit strobing of the multiplexed display. The digital processor combines the counting, storage, and data multiplexing functions with the logic necessary to control the analog processor. Output buffers provide the polarity sign, digit strobe and multiplexed BCD data outputs. The digit scan is an interlaced format of digits 1, 3, 2, and 4.

4–37. The digital processor has a built-in overrange flashing circuit. The presence of a count of 2000 or greater in the BCD counter causes the 3½ digit display to blink off during the zero cycle resulting in a flash rate equal to the sampling rate of four readings per second.

4–38. Decoder driver U702 translates the BCD information from the digital processor to drive the segments of LED numeric readouts DS750, 751 and 752. The common cathodes of these LEDs are strobed by the digital processor U700 and related buffers. DS750 is the least significant digit (LSD).

4–39. The display is tested by illuminating all seven segments in each numeric. Display test is activated by simultaneously pushing the V and MA pushbuttons S3 and S4. U701 then inverts this signal and activates the test mode in U702.

4–40. The numeric "1" is formed by two segments in common anode LED DS753 which also includes the polarity sign. The "1" segments are driven from U701. The polarity plus symbol is controlled by Q700 and pushbutton switch S2 which illuminates the polarity sign only in the DC modes. Q701 strobes DS753 on command from U700.

4–41. Decimal point illumination is automatically controlled by the range pushbutton switches S7 thru S12.

4–42. The clock signal for the analog and digital processor is generated by the dc-to-dc power converter in the power supply. For optimum normal mode rejection in the analog processor the clock frequency must be a direct multiple of the power line frequency. For 60-Hz power the clock is set to 24.576 kHz and for 50-Hz power it is set to 25.6 kHz.

4–43. DC-to-DC Power Converter (Reference Designator 800 Series).

4–44. The dc-to-dc power converter transforms the +5 volt levels. Q800 and Q801 alternately switch step-up autotransformer T800. The switching frequency is adjustable with R801 and should be set as stated previously in paragraph 4–42. The square wave output from T800 is rectified by full-wave rectifier diodes CR801 and CR802 to provide +12 volts and CR800 and CR803 to provide −12 volts. Capacitors C803 and C804 act as output filters.

4–45. R800 couples the clock signal from the dc-to-dc power converter to digital processor U700.

4–46. AC Power Supply (Reference Designator 900 Series).

4–47. The ac power line is connected to T900 which transforms the line voltage to provide a 10-volt dc supply using bridge rectifier CR900 and filter capacitor C900.

4–48. Integrated circuit, three-terminal, 5-volt regulator U900 regulates the output from the bridge rectifier. All 5-volt circuits and the dc-to-dc power converter are supplied from U900.

4–49. Rechargeable Battery Supply (Optional).

4–50. The rechargeable battery power supply powers the DMM whenever line voltage is removed or drops below the minimum needed to drive regulator U900. Four nickel cadmium "C" cells are the battery power source.

4–51. The four batteries are wired in series to provide nominally 4.5 volts. Q900 acts as the battery cutout switch to guard against battery reversal and to automatically switch the batteries out of the circuit when ac power is available through U900. The battery output voltage is sufficiently stable during discharge so that the battery supply substitutes for regulator U900 in the +5 volt dc supply.

WARNING

USE ONLY NICKEL CADMIUM "C" CELLS TO POWER THE MODEL 3028A. USE OF ALKALINE OR CARBON ZINC CELLS MAY CAUSE DAMAGE AND VOID THE WARRANTY.

4–52. To charge the batteries, the POWER pushbutton S1 is set to OFF and ac power is applied. The higher voltage tap on T900 is then activated and the batteries are charged through DS900 and R902 by dc power from bridge rectifier CR900. The instrument is not operating when batteries are being charged. The nominal charging current of 200 mA is maintained throughout the charge cycle by the regulating characteristics of lamp DS900.

SECTION 5
MAINTENANCE AND CALIBRATION

5–1. INTRODUCTION.

5–2. This section contains information required to maintain the instrument within specifications. The following paragraphs detail:

a. Performance Assurance Checks.

b. Calibration Procedures.

c. Fault Finding (Troubleshooting) details.

d. Preventive Maintenance.

5–3. The instrument is designed with premium components. Like other Ballantine instruments, it will provide many years of satisfactory service. Ballantine recommends that performance assurance checks and preventive maintenance procedures be performed on the following schedule:

a. Routine laboratory service every 12 months or 1,000 hours of use whichever comes first.

b. Service in the field or in extended environments every six months or 450 hours of use whichever comes first.

5–4. Full NBS traceable calibration should be performed once each year. Normally the user will provide recalibration services in his plant. If required, Ballantine will gladly provide this calibration service at our Boonton, N. J. service center for a nominal charge.

5–5. REQUIRED TEST EQUIPMENT.

5–6. Table 5–1 provides a list of test equipment required to properly check, calibrate, and maintain the instrument. Equivalent test equipment meeting all the minimum requirements may be substituted if the recommended items are not available.

TABLE 5–1. REQUIRED TEST EQUIPMENT

Instrument Type	Purpose	Recommended Model	Specifications
DC Voltage Calibrator	DC Voltage Calibration	Fluke 332B	10 mV to 1100 V dc. Five-digit resolution. 0.03% accuracy.
AC Voltage Calibrator	AC Voltage Calibration	H-P 745A/746A	10 mV to 1100 V ac. 10 Hz to 110 kHz. Five-digit resolution. 0.05% accuracy.
DC Current Calibrator	DC Current Calibration	Fluke 382A or 760A	10 μA to 1 A dc. Five-digit resolution. 0.05% accuracy.
Resistance Standard	Ohmmeter Calibration	Shallcross 883	10Ω to 10 MΩ. ±0.1% accuracy. Decade dials.
AC/DC True RMS Voltmeter	Line Voltage Measurement	Ballantine 3620A	10 mV to 1 kV, dc and ac true rms. 0.25% accuracy. 4½-digit resolution. 1 μV resolution.
Digital Multimeter	Troubleshooting Tool	Ballantine 3028A	DC volts to 1.2 kV. AC volts to 1.2 kV. 20 Hz to 100 kHz. LOΩ, 100 to 2 MΩ. HIΩ, 1 kΩ to 20 MΩ. AC current to 2A. DC current to 2 A. 3½ digits.
Oscilloscope with probes	Troubleshooting Tool	Ballantine 1010B with 10601B probes	Dual Trace. 5 mV, dc to 10 MHz. 100 ns/cm to 1 sec/cm. 10:1 divider probes.
AC Current Source	AC Current Calibration	Fluke 760A	10 μA to 1 A, ac ±0.2% accuracy.
Line Control Variac	Set Line Voltage	General Radio W5MT3AW	0 V to 135 V (0 V to 270 V).
Frequency Counter	Set A to D Clock frequency	Ballantine 5725B or 5500B	6 digits. 10 Hz to 1 MHz.

TABLE 5–2. DC VOLTAGE ACCURACY CHECK

DC Voltage Calibrator Voltage	DMM		Readout Display Limits
	Range	Function	
0.0000	100 m	VDC	–00.1 to +00.1
+0.0100	100 m	VDC	+09.8 to +10.2
+0.1000	100 m	VDC	+99.8 to +100.2
–0.1000	100 m	VDC	–99.8 to –100.2
+0.1800	100 m	VDC	+179.7 to +180.3
+1.0000	1	VDC	+.998 to +1.002
+10.000	10	VDC	+9.98 to +10.02
+100.00	100	VDC	+99.8 to +100.2
+1000.0	1000	VDC	+998 to 1002

TABLE 5–3. DC CURRENT ACCURACY

DC Current Calibrator	DMM	
	Range	Readout Limits
00.0 μA	100 μ	–00.2 to +00.2
+100 μA	100 μ	+99.5 to +100.5
+1.000 mA	1 m	+.995 to +1.005
+10.00	10 m	+9.95 to +10.05
+100.0	100 m	+99.5 to +100.5
+1000	1000 m	+995 to +1006

TABLE 5–4. AC VOLTAGE ACCURACY

AC Voltage Calibrator		DMM	
Voltage	Frequency	Range	Display Limits
0000 mV	500 Hz	100 m	00.0 to 00.5
10.00 mV	500 Hz	100 m	09.7 to 10.3
100.00 mV	500 Hz	100 m	98.8 to 101.2
100.0 mV	5 kHz	100 m	98.8 to 101.2
100.0 mV	50 kHz	100 m	97.8 to 102.2
180 mV	500 Hz	100 m	178.1 to 182.0
180 mV	50 kHz	100 m	175.8 to 184.2
1.000 V	500 Hz	1	.988 to 1.012
1.000 V	5 kHz	1	.988 to 1.012
1.000 V	50 kHz	1	.978 to 1.022
10.00 V	500 Hz	10	9.88 to 10.12
10.00 V	50 kHz	10	9.78 to 10.22
100.0 V	500 Hz	100	98.8 to 101.2
100.0 V	50 kHz	100	97.8 to 102.2
1000.0 V	500 Hz	1000	988 to 1012
1000.0 V	50 kHz	1000	978 to 1022

5–7. PERFORMANCE ASSURANCE CHECKS.

5–8. The performance assurance checks are "in-cabinet" checks that compare the instrument with the applicable performance specifications. The sample performance test record, Form 5–1, may be used or duplicated to provide permanent performance test records. Beginning with incoming inspection checks, periodic performance assurance checks should be made in the sequence detailed below and before any attempt is made to calibrate the instrument. The performance assurance checks should also be used as part of the troubleshooting procedure and before returning the instrument to regular service after repair, recalibration, or extended storage. *All checks are made at 23°C ±2°C and with COMMON connected to power line earth ground. Use ac power input.*

Note

Prior to making any of the following performance assurance checks set ac line voltage to 120 volts (or 100, 200, or 240 volts). If battery power is used, charge batteries at least 8 hours. Exercise each of the 12 pushbuttons several times to clean switch contacts by self-wiping action.

5–9. Power Supply and Display Check.

5–10. To check the power supply regulation and the display proceed as follows:

a. Connect the instrument to the ac power line through a Variac voltage control unit. Monitor ac voltage with the true rms responding ac voltmeter.

b. Set DMM pushbuttons as follows:

Mode	(S2)	AC
Function	(S4)	mA
Range	(S7)	100μ

c. Set line voltage to 120 ± 2 volts (or 100, 220 or 240 volts).

d. Depress POWER pushbutton switch S1 to "ON."

e. Observe that the digital display reads 00.0 to 00.3.

f. Depress V and mA pushbuttons S3 and S4 simultaneously.

g. Observe that the display reads 888 as an indication that the display performs satisfactorily.

h. Release V pushbutton S3 but depress mA pushbutton S4 to retain current function.

i. Lower line voltage to 102 V (or 87, 196 or 208 volts) and observe that the DMM display does not change. This checks low line voltage operation.

j. Raise line voltage to 130 volts (or 108, 245 or 260 volts) and observe that the DMM display does not change. This checks high line voltage operation. Reset line to 120 volts (100, 220 or 240 volts).

5–11. Battery Check.

Note

This battery check is required only when a rechargeable battery option, such as Option 05, is installed.

a. Continue as in Step 5–10(j) but disconnect ac power cable from the rear panel receptacle of the DMM. Connect earth ground to rear panel ground lug.

b. Observe that the batteries power the unit and that the display does not change.

c. Depress the "V" pushbutton S3. (This releases S4, the mA pushbutton.)

d. Depress the 1000 k and 10 M pushbuttons S11 and S12 simultaneously.

e. Observe that the display reads greater than 5.00 to indicate that the batteries are charged. Fully charged batteries will check at above 5.35.

5 -12. DC Voltage Accuracy Check.

5–13. To check the dc voltage accuracy of the instrument proceed as follows:

a. Set Mode pushbutton switch S2 to "DC."

b. Set function pushbutton switch S3 to "V."

c. Set POWER pushbutton switch S1 to "ON."

d. Depress range pushbutton switch S7 for 100 mV.

e. Connect a short across the V–Ω and COMMON input connectors.

f. Note a display reading of 0.00 ± 2 counts.

g. Remove the short from V–Ω and COMMON.

h. Connect the DC voltage calibrator positive output to the V–Ω input connector of the DMM and connect the negative calibrator output to the COMMON connector.

i. Proceed to check dc voltage accuracy at each setting of the voltage calibrator listed in Table 5–2. In each case the digital readout display of the DMM should be within the tolerance shown.

j. For negative readings reverse input leads at the DC voltage calibrator.

5–14. DC Current Accuracy Checks.

5–15. Set the DMM controls as follows:

a. Power (S1) ON

b. Mode (S2) DC

c. Function (S4) mA

d. Range (S11) 1000

5–16. Connect the mA input connector of the DMM to the positive output of the dc current calibrator and the COMMON input connector to the negative terminal of the current calibrator.

TABLE 5–5. OPTIONAL AC CURRENT ACCURACY CHECK

AC Current Calibrator		DMM	
Current	Frequency	Range	Display Limits
0000	500 Hz	100 μ	00.0 to 00.5
100.0 μA	500 Hz	100 μ	98.8 to 101.2
100.0 μA	50 kHz	100 μ	97.3 to 102.7
1.000 mA	500 Hz	1 m	.988 to 1.012
1.000 mA	50 kHz	1 m	.973 to 1.027
10.000 mA	500 Hz	10 m	9.88 to 10.12
10.000 mA	50 kHz	10 m	9.73 to 10.27
100.00 mA	500 Hz	100 m	98.8 to 101.2
100.00 mA	50 kHz	100 m	97.3 to 102.7
1000.0 mA	500 Hz	1000 m	973 to 1.027
1000.0 mA	1 kHz	1000 m	973 to 1.027

TABLE 5–6. RESISTANCE ACCURACY CHECKS

Resistance Standard	Function	DMM	
		Range	Display Limits
0000	LOΩ	100	00.0 to 00.6
100.00	LOΩ	100	99.7 to 100.8
1.0000 k	LOΩ	1 K	997 to 1004
1.0000 k	HIΩ	1 K	997 to 1003
10.000 k	LOΩ	10 K	9.97 to 10.03
10.000 k	HIΩ	10 K	9.97 to 10.03
100.00 k	LOΩ	100 K	99.7 to 100.3
100.00 k	HIΩ	100 K	99.7 to 100.3
1.000 M	LOΩ	1000 K	994 to 1006
1.000 M	HIΩ	1000 K	997 to 1003
1.000 M	HIΩ	10 M	9.94 to 10.06

TABLE 5–7. DC POWER SUPPLY LIMITS

Supply	Test Points	Voltage Limits
+5	TP5	+4.20 to 5.30
+12	TP9	+11.3 to +14.7
−12	TP7	−11.3 to +14.7

5–17. Check the accuracy at each setting of the dc current calibrator listed in Table 5–3. In each case the displayed readout must be within the tolerances shown.

5–18. AC Voltage Accuracy Checks.

5–19. Set the DMM controls as follows:

a. Power (S1) ON
b. Mode (S2) AC
c. Function (S3) V
d. Range (S11) 1000

5–20. Connect the ac voltage calibrator to the V–Ω and COMMON input connectors of the DMM.

5–21. Check the accuracy at each setting of voltage and frequency of the ac voltage calibrator as listed in Table 5–4. In each case the displayed readout must be within the tolerances shown.

5–22. AC Current Accuracy Checks.

5–23. AC current checks are optional. The current shunts within the instrument are used for both ac and dc. They are noninductive and have virtually no effect on frequency response which is determined by the ac to dc converter fully tested in paragraph 5–18 for ac voltage accuracy. Current accuracy is therefore checked for both ac and dc in paragraph 5–14. The following procedure is therefore given for reference only and need not be regularly performed. AC current accuracy checks are not required for the Performance Test Record Form 5–1.

5–24. Set DMM controls as follows:

a. Power (S1) ON
b. Mode (S2) AC
c. Function (S4) mA
d. Range (S11) 1000

5–25. Connect the ac current calibrator to the mA and COMMON input connectors of the DMM.

5–26. Check the accuracy at each setting of current and frequency of the ac current calibrator as listed in Table 5–5.

5–27. Ohms Ranges Accuracy Checks.

5–28. Set DMM Controls as follows:

a. Power (S1) ON
b. Function (S6) LOΩ
c. Range (S7) 100

5–29. Connect the Resistance Standard to the V–Ω and COMMON input connectors of the DMM.

5–30. Check the resistance accuracy of the HIΩ and LOΩ ranges of the DMM at each setting of the resistance standard listed in Table 5–6. In each case the displayed readout must be within the tolerances shown.

5–31. CALIBRATION PROCEDURES.

5–32. If any of the Performance Assurance checks show an out-of-tolerance condition, recalibration will be required. Table 5–1 lists the test equipment required to completely calibrate and certify the instrument. If the instrument cannot be properly adjusted refer to the troubleshooting and fault finding procedures detailed in paragraph 5–55.

Note

Only a qualified service technician with properly calibrated test equipment should service this instrument, since internal voltages may cause shock hazard. Calibrate at 23°C ± 2°C and connect COMMON to earth ground.

5–33. Removal of Covers. The top and bottom covers of the plastic enclosure are fastened together by four screws which are accessible through the bumper feet at the bottom cover. To remove the covers first disconnect ac power cord. Then remove the handle by pulling carefully and firmly on the handle detents until both sides of the handle snaps out of their second detent. Then remove the four screws and carefully pull the top cover up and out from the side sections. Take care not to misplace the four spacer sleeves used to space the top cover on the side supports. These spacers support the unit and provide electrical connections for the metallic coating shield on the top cover and side supports. Always remove NiCad batteries at this point if Option 05 is installed. The side sections may then be removed by pulling up from the bottom cover. The front and rear panels will now be free of support. The printed wiring board may be separated from the bottom cover by removing the retaining screws accessible at the top of the printed wiring board.

Note

When making final calibration always have the bottom cover, panels, and side supports installed with proper electrical interconnection to the metallic coating since it serves as a guard shield to minimize unwanted noise pickup.

5–34. Preliminary Inspection.

5–35. Always check the voltmeter for mechanical damage, loose parts, faulty solder joints, burned resistors, etc. Use a low wattage (25 watts) grounded soldering iron to make repairs and always replace components with exact equivalents to be certain that all performance specifications can be obtained. Use heat shunts when soldering diodes and semiconductors. Do not overhead circuit board printed wiring and pads.

5–36. Internal Adjustments and Test Points.

5–37. See Figure 5–1 for the location of internal adjustments and test points.

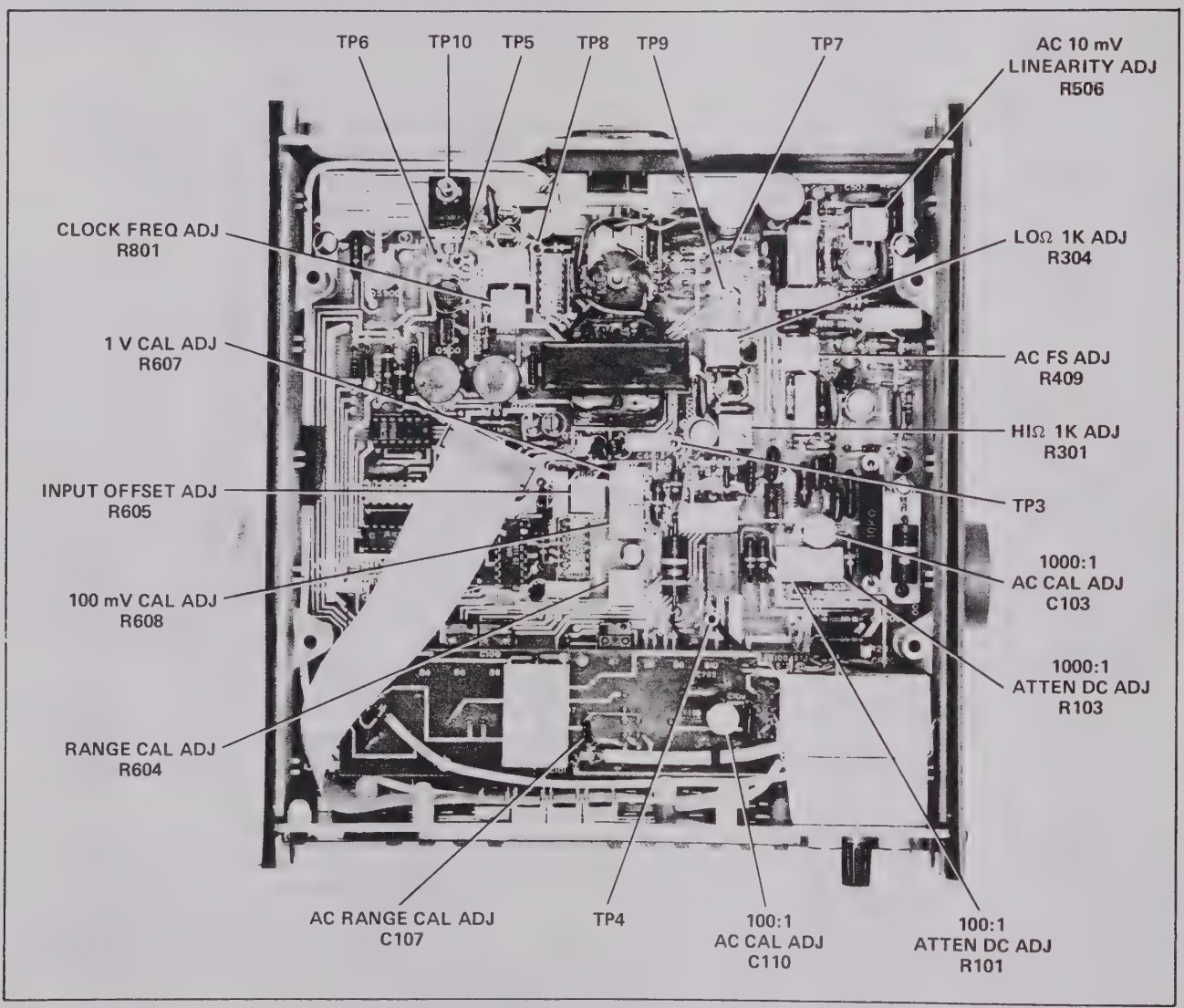


Figure 5–1. Location of Internal Adjustment and Test Points

5–38. Initial Power Supply Checks.

5–39. The 3028A has no power supply adjustments but line voltage regulation should be checked before calibration. Vary ac power line voltage with a variac from 102 to 130 volts (or over the limits given for the operating range selected when using Option 06). Monitor the three dc power supply voltages of the DMM and observe voltages listed in Table 5–7 with a dc voltmeter.

5–40. Calibration.

5–41. All calibration is performed with ac power turned ON and ac line voltage set to 117 volts (or in the middle of the range selected when using Option 06).

CAUTION

Always perform the calibration in the sequence indicated below.

5–42. Clock Frequency Adjust R801.

a. Connect digital frequency counter input to Test Point 8. Ground the counter input to the COMMON input connector of the DMM.

b. Adjust R801 for a counter reading of 24.56 kHz when using 60 Hz power or 25.6 kHz when using 50 Hz power. The setting should be within ± 150 Hz.

5–43. Input Offset Adjust R605 and DC Polarity Reversal Test.

a. Set DMM to DC, V, and 100 m.

b. Short input connector V–Ω to COMMON.

c. Adjust R605 (Input Offset Adj.) for a display reading of 00.0. Note that the display does not change ± 1 count more than ten times in ten seconds.

d. Remove input short and connect a dc voltage to V–Ω and COMMON. Set the input voltage for any display reading between +170.0 and +190.0 and note display reading.

e. If batteries Option 05 is installed disconnect ac power and observe that reading noted in Step d. does not change more than ± 1 digit. Charge batteries or troubleshoot if reading changes more than ± 1 digit. Restore ac operation for remainder of test.

f. Reverse input leads at the V–Ω and COMMON connectors. Observe that the negative of the display reading noted in Step d. does not change more than ± 2 digits for turnover error. If the change is greater compromise the adjustment of R605 by averaging the setting between steps c. and f. For optimum results it may be necessary to add R603 which is a resistor in the range of 360 K to 910 K. R603 is typically 560 K.

5–44. Range Cal Adjust R604.

a. Set R607, the 1 volt adjust and R608 to 100 mV adjust potentiometers at the center of their range.

b. Connect the dc voltage calibrator to the V–Ω and COMMON input connectors of the DMM. Apply +190.00 mV.

c. Set DMM controls.

d. Adjust R604 (2 V Adj.) for a DMM display reading of +190.0 ± 10 digits.

5–45. 100 mV Cal Adjust R608.

a. Maintain the test set up of paragraph 5–44.

b. Adjust R608 (100 mV Cal Adj.) for a DMM display reading of exactly +190.0.

5–46. 1 V Cal Adjust R607.

a. Maintain the test set up of paragraphs 5–44 and 5–45.

b. Set DMM to DC, V, and 1.

c. Set dc voltage calibrator to +1.9000 volts.

d. Adjust R607 (1 V Cal Adj.) for a DMM display reading of exactly +1.900.

5–47. LOΩ 1 K Cal Adjust R304.

a. Set DMM to LOΩ and 1 K.

b. Connect resistance standard to V–Ω and COMMON connectors and set standard to 1.900 k Ω.

c. Adjust R304 (LOΩ/1 k Cal Adj.) for a DMM display reading of 1.900. If R304 does not cover the range, select R303 by changing to 7.50 k, 8.25 k or 9.06 kΩ or replace Q302.

5–48. 1000 to 1 Attenuator DC Adjust R103.*

a. Set DMM to LOΩ and 10 kΩ.

b. Connect 19.00 kΩ resistance standard to the DMM input.

c. Adjust R103 for a DMM display reading of 19.00.

d. Disconnect Resistance Standard.

5–49. 100 to 1 Attenuator DC Adjust R101.

a. Set DMM to DC, V, and 1000.

b. Connect dc voltage standard to the V–Ω and COMMON input connectors. Apply +1000.0 V.

c. Adjust R101 (100 to 1 Att. DC Adj.) for a DMM display reading of +1000.

5–50. Recheck 100 Volt Range DC Calibration.

a. Set DMM to DC, V, and 100.

b. Connect dc voltage standard to the DMM and apply +100.00 V.

c. DMM display should read +100.0. If required touch up R103 to obtain +100.0. If the display error was more than ± 3 digits repeat paragraph 5–48.

*Not used when R102 is 90 kΩ, 1 W, 0.05%.

5–51. HIΩ 1 K Cal Adjust R301.

a. Set DMM to HIΩ and 1 K.

b. Connect 1.9000 kΩ resistance standard to the V–Ω and COMMON connectors.

c. Adjust R301 (HIΩ 1 k Cal Adj.) for a DMM display reading of 1.900.

d. Switch DMM to LOΩ and check that DMM display reads 1.900 ± 3 digits or repeat paragraph 5–47.

e. Change resistance standard to 190.00 kΩ and set DMM to HIΩ and 100 k. Check that DMM display reads 190.0 ± 3 counts or repeat steps a through c.

5–52. AC 10 mV Linearity Adjust R506.

a. Set DMM to AC, V, and 100 m.

b. Apply 10 mV at 400 Hz.

c. Adjust R506 (AC 10 mV LIN Adj.) for a DMM display of 01.0.

5–53. AC Full Scale Adjust R409.

a. Set DMM to AC, V, and 100 m.

b. Short V–Ω to COMMON input connectors.

c. Check that DMM display reads 00.0 to 00.4.

d. Remove input short and connect the ac voltage calibrator to V–Ω and COMMON.

e. Apply 190.00 mV at 400 Hz.

f. Adjust R409 (AC FS Adj.) for a DMM display reading of 190.0.

g. Repeat steps 5–52 and 5–53.

5–54. AC 1000 to 1 Cal Adjust C103 and Range Cal Adjust C107.*

a. Set DMM to AC, V, and 1000.

b. Connect the ac voltage calibrator to the V–Ω and COMMON input connectors.

c. Apply 1000.00 volts at 400 Hz.

d. Observe that the DMM display reads 990 to 1010. If not recheck paragraphs 5–52 (R409), 5–49 (R101) and 5–48 (R103).

e. Increase ac voltage calibrator frequency to 50 kHz.

f. Adjust C103 (AC 1000 to 1 CAL ADJ.) until the display reads 997 to 1002.

g. Set ac voltage calibrator to 5 kHz and note that the display reads 997 to 1003. If display reads above 1003 set calibrator to OFF and carefully trim 2 mm from the end of twin lead capacitor C107 (AC RANGE CAL ADJ). Cut diagonally to provide a long leakage path. Check adjustment of C103 at 50 kHz after each trim.

*Simulate capacitive effects of top cover when performing this adjustment.

If display reads below 997 at 5 kHz, replace C107 with a new and longer twin lead and repeat the above trimming procedure until the 5 kHz and 50 kHz response points are 990 to 1010 and 994 to 1005 respectively.

CAUTION

Always turn ac voltage calibrator OFF to prevent shock hazard when trimming C107.

5–55. AC 100 to 1 Cal Adjust C110.*

a. Set DMM to AC, V, and 10.

b. Connect the ac voltage calibrator to the DMM input.

c. Apply 19.000 volts at 400 Hz.

d. Observe that the DMM display reads 19.00 ± 3 digits.

5–56. TROUBLESHOOTING AND FAULT FINDING.

5–57. The troubleshooting procedures should only be performed when the instrument cannot be calibrated with the calibration procedures listed in paragraphs 5–31 through 5–54. Should the instrument be inoperative or out of specification, follow the fault finding procedures listed below.

5–58. Carefully examine the instrument and check for any visual evidence of trouble. Check for broken wires, burned resistors, loose components, shorts, or open or defective solder joints on the printed circuit board. Check for separation of printed circuit board lands and pads. Check for open, defective, or intermittent switches. Check that connectors are clean and will mate properly. Check that instrument circuit ground is properly connected to the metal coating shield on the plastic case top, bottom and side supports. Check that the power line earth ground is connected only to the front and rear panels. Troubleshoot with COMMON connected to power line earth ground.

5–59. Understand and be familiar with the circuit theory of Section 4. Use the functional block diagram of Figure 4–1 and the schematic diagram to isolate the probable circuit areas which may cause the problem. Always check the power supply voltages. Check for oscillations in the circuitry by using an oscilloscope. Then refer to the fault finding and troubleshooting hints for that circuit. Table 5–8 gives some probable corrections for specific symptoms.

5–60. **NOTE:** All tests and calibration procedures listed herein consider the normal service conditions of 15°C to +35°C. Should a service condition temperature range of 20°C to 40°C be required then all the calibration settings listed above must be offset to reflect the increased temperature range. Calibrate the instrument with the ambient temperature at 22°C to 25°C and make adjustments by subtracting two least significant digits from the digital display to reflect the higher service condition range of 20°C to 40°C.

5–61. FUSE REPLACEMENT.

5–62. The ac power line fuse F50 is located on the inside of the rear panel. To replace the fuse, remove the covers as described in paragraph 5–33, remove the defective fuse, and snap in the replacement fuse.

5–63. PREVENTIVE MAINTENANCE.

5–64. **Cleaning.** The instrument should be cleaned as often as operating conditions require. Thoroughly clean both the inside and outside of the instrument. Remove dust from inaccessible areas with low pressure compressed air or vacuum cleaner. Use alcohol applied with a cleaning brush to remove accumulations of dirt or grease from connector contacts and component terminals. Clean the exterior of the instrument and the front panel with a mild detergent mixed with water, applying the solution with a soft, lint-free cloth.

5–65. **Repair and Replacement.** Repair and replacement of electrical and mechanical parts must be accomplished with care and caution. Printed circuit component boards can become warped, cracked, or burnt from excessive heat or mechanical stress. The following repair techniques are suggested to avoid inadvertent destruction or degradation of parts and assemblies.

a. Use a low-heat capacity soldering iron (Weller Model No. W-TCP 35 watt) soldering iron with a 700°F tip 1.5 mm (1/16") to 2.5 mm (3/32") wide.

b. Be sure that the soldering iron tip and the cabinet and COMMON connectors are securely tied to "earth" ground. This avoids possible overvoltage damage to semiconductors and capacitors.

c. To desolder components, use a commercial "solder sipper," (SOLDA PULLT manufactured by Edsyn Products or equivalent) or use solder-removing SODER-WICK, size 3, manufactured by SOLDER REMOVAL CO., Covina, California.

d. To remove a component, clip a heat sink such as long nose pliers, tweezers, or alligator clips onto the component lead and as close to the body of the component as possible. This assures minimum heating of the component while soldering.

Place the soldering iron directly on the component lead on the printed circuit conductor side of the board. Use a desoldering aid to remove all solder and free the component lead.

Straighten the bent over component lead with long nose pliers.

Pull the component out of the hole.

If a component is obviously faulty or damaged, simply clip the leads close to the body of the component and remove the remaining leads thru the conductor side of the circuit board.

CAUTION

Always use a short soldering cycle since excessive or prolonged heat may destroy the laminate bond and lift the copper conductors from the circuit board or cause immediate degradation or latent damage to the components.

e. Always clean the component lead holes by heating the solder on the circuit board conductor pad, then quickly remove the soldering iron and insert a pointed non-metallic object such as a toothpick to clean the hole. Never let solder cover the hole, since the incoming new component lead may then push the pad from the circuit board.

f. To install a new component, straighten and shape the leads. Insert the component into the proper holes. Bend the leads at the conductor side of the circuit board so they fall over the pad and extend over the foil of the incoming conductor path. Cut the bent lead approximately 2.5 mm (3/32") from the hole.

Clip a heat sink to the component lead at the body of the component. Heat the lead and pad with a soldering iron and use fresh solder (60-40) as required to cover the lead and form a meniscus over the hole to assure a good electrical connection.

g. Clean excess flux from the connection and surrounding area. Use TF Freon spray cleaner (such as Miller Stevenson Chemical Co., Type MS-180, Ballantine P/N 80-10004-0A) and use light air pressure (5 to 20 PSIG) and a clean soft brush to clean board and components. Use a humidity seal spray (such as Humiseal, Columbia Technical Corp., 1015, Ballantine P/N 80-10005-0A) to seal board and protect against humidity.

Note

Do not touch cleaned board or excessively handle components to avoid unwanted leakage which may affect performance when exposed to high humidity.

h. Always replace a component with its exact duplicate as specified in the parts list.

5–66. REPLACING PUSHBUTTON SWITCHES.

a. Pushbutton switches may be disassembled for replacement of worn switch wipers and return springs. This saves unsoldering the multicontact switch. New parts must be taken from replacement switch assemblies which may be ordered as spare parts. To obtain access to pushbutton switches remove front panel and pushbuttons. Hold the return spring. Use a long nose plier to pull up and away on the "U" shaped retainer. Remove the spring. On S1 and S2 free the detent spring and pin. Carefully slide the switch bar out the rear of the switch. Access is then obtained to the individual switch contact sliding springs. Clean the switch and lubricate contacts.* Place the new contact springs into the switch bar and carefully reassemble the switch bar thru the rear of the switch assembly. To simplify assembly

reinsert two switch contact slider springs at a time. When all contact slider springs are in place and the push bar is fully extended out the front of the housing, replace the detent, the return spring and the "U" retainer. Operate the rebuilt switch several times to be sure all parts are in place. Then reassemble and test the instrument.

b. It is recommended that all contact slider springs be replaced in all 12 switches. If the entire switch assemblies are to be replaced, unsolder the small upper printed wiring board. Then use a solder pot or solder wave (rather than soldering iron and solder sucker) to remove the switch assemblies.

c. Do not clean switch with Freon or other solvents. Periodically lubricate all switch contacts with a light application of spray lubricant.*

*Use switch contact lubricant and cleaner such as Electrolube Contact Treatment Oil 2AX, Ballantine P/N 80100090A, or equivalent.

TABLE 5–8. TROUBLESHOOTING AIDS

1. Digital display does not illuminate when power switch is "ON."	1. AC power cord not properly inserted or connected. Check power line fuse F50. Check condition of Q800 and Q801, the DC/DC converter drivers, and U900 +5 volt regulator as well as rectifiers, CR900, and power switch S1. Check power supply voltages: +12 volts measures between +11.3 to +14.7 V +5 volts regulated measures between +4.2 to +5.3 V −12 volts measures between −11.3 to −14.7 V +5 volts unregulated measures between 7 and 13.5 V Replace appropriate components if measurements indicate out of tolerance voltages. Check for other faulty components that cause heating and excessive current drain. Check display drivers U701 and U702. Check Display Test. Replace components if fault is found.
2. Display does not read 0.000 to ±.0001 with 1 V range, V and DC function and V–Ω connector shorted to common.	2. Check clipping diodes CR601 and CR602, if installed, or U300. Short pin 15 of U600 to the common input connector. If display does not show −00.2 to +00.2, check or replace U600 and U700, and display driver circuitry. Check Q601 and measure 6.8 to 9.5 volts across this voltage reference zener. Adjust R605 (Input Offset Adj.) per paragraph 5–43.
3. 10% of Full Range Check. Connect +100 mV DC to the V–Ω and COMMON connectors. Select V and DC FUNCTION and 1 V RANGE.	3. If readout does not read 0.1000, connect input signal to the junction of R600 and S12A. If the display now reads 0.1000, check S12A, S5E, S6B, S3B, S2E, and S12B for poor connections. If the display does not read +0.100, transfer the input signal to the junction of CR601 and CR602. Check CR601 and CR602 if the display reads 0.100. If the display does not read 0.100, transfer the input signal to pin 15 of U600. If the display does not read 0.100, check U600, U700 and their related components.

TABLE 5–8. TROUBLESHOOTING AIDS (Continued)

4. Display Test Check. Push V and mA pushbuttons.	4. If the display does not read 888, check or replace U702, the decoder driver. Check the +5 volt regulated supply to see that it measures +4.2 to +5.3 volts. If one digit is not functioning, check U701. If some segments of the display are not lit, sequentially tie pins 9 thru 15 of U702 to the +5 volt supply and observe that one row of segments of the display are lit at any one time. This checks faulty U702 decoder driver. Also check RN700 and the LED readout DS750 thru DS752 and its cable assembly.
5. Full Range Check. Connect +1.900 volts DC to the V–Ω and COMMON connectors. Select V and DC FUNCTION and 1 V RANGE.	5. Observe +1.900 ± 2 digits. If display is not in tolerance, recalibrate R608 and R607 the 100M volt and 1 volt RANGE calibrators. Also check switches S5A, S7E, S6F, S4D and S9B. Check reference diode Q601. Check clock frequency adjustment R801. Use a frequency counter to check cycle frequency, 24.56 kHz for 60 Hz operation, and 25.6 kHz for 50 Hz power line operation. If either "1" digit of display or "+" symbol does not light up, check DS753, Q700, Q701, U701, S2B, S3D, and S4E.
6. Check negative sign. Repeat step 5 but apply –1.8 V DC.	6. Negative sign must illuminate on DS753. If not, check U700, U701, Q700, and Q701. If display reads more than 3 digits difference between plus input polarity (step 5) and minus input polarity (step 6), check for leaky diodes CR601 and CR602. Check U3 for excessive input current and clean P. C. board since leakage may exist at the input leads between V–Ω connector and pin 15 of U600. Check adjustment of R605 (Input Offset Adj.) since it also controls polarity turnover error. See paragraph 5–43.
7. Decimal Point Test. Select DCmA FUNCTION AND 1000 mA RANGE.	7. Observe that no decimal point is lit and the display reads –002 to +002 Select 100 mA RANGE and observe that the display reads –00.2 to +00.2. Select 10 mA RANGE and observe that the display reads –0.02 to +0.02. Select 1 mA RANGE and observe that the display reads –.002 to +.002. Select 100 μA RANGE and observe that the display reads –00.2 to +00.2. If any of these decimal points do not light check the respective LED (DS750 thru DS752). Check R705, S7C, S9E, S10E, and S12D.

TABLE 5–8. TROUBLESHOOTING AIDS (Continued)

8. Accuracy Tests. See details in Performance Assurance Checks (paragraph 5–7).	8. DC volt calibration not OK, check input voltage divider R101, R102, R103, R104, R600, R601, and their associated switches. KΩ tests not OK then check U300, constant correct source Q300, Q301 and Q302, and their associated components. If 100 Ω RANGE faulty, also check R303 and R304 as well as S5B and S6E. Also check S3E, S4B, S7B, S10D, and S5C. DC mA tests not OK, check current shunt resistor DIP RN200 as well as condition of CR200 thru CR204. Check associated switches. AC voltage tests not OK, check AC converter U400, Q400, Q401, U500, and associated switches and components. AC mA tests not OK, recheck DC mA tests and AC voltage tests. Then check S4A, S2D, S2A, and S3A.
9. Intermittent Switches.	9. When the multimeter has been stored for a period of time or has been exposed to caustic fumes, acid fumes, oil fumes, hydrogen sulfide, or other contaminants, the pushbutton switches may become noisy or intermittent even though specially treated high-quality silver-plated contacts are used throughout. Push each button ten or more times to permit self-wiping action of switches to clean the contacts and eliminate the problem. If at the end of life or after extensive exposure the switches continue to be noisy, they should be replaced with new components. Periodically lubricate switches with silicone spray contact lubricant.
10. Battery Operation Not Functional.	10. Check that batteries are charged and or charge batteries for 8 to 16 hours. Replace batteries when they do not power DMM for at least 3 hours. Open top cover and check that batteries are installed and seated properly. Observe that ballast lamp DS900 is installed and lights brightly to indicate batteries are charging when POWER switch (S1) is OFF and ac line power is applied.

PERFORMANCE TEST RECORD

BALLANTINE MODEL 3028A, OPTION _____* SERIAL NUMBER _____

1. 120-Volt Check (0.00 ±3LSD) _____ (✓)
2. Display Test (888) _____ (✓)
3. 102-Volt Lo Line Check (0.00 ±3LSD) _____ (✓)
4. 130-Volt HI Line Check (0.00 ±3LSD) _____ (✓)
5. Battery Test (>5 volts display reading) _____ (✓)
   (Option 05 installed)
6. DC Voltage Calibration Check

Calibrator Voltage	DMM			
	Range	Function	Readout Display Limits	Reading
0.0000	100 m	VDC	−00.1 to +00.1	
+0.0100	100 m	VDC	+09.8 to +10.2	
+0.1000	100 m	VDC	+99.8 to +100.2	
−0.1000	100 m	VDC	−99.8 to −100.2	
+0.1800	100 m	VDC	+179.7 to +180.3	
+1.0000	1	VDC	+.998 to +1.002	
+10.000	10	VDC	+9.98 to +10.02	
+100.00	100	VDC	+99.8 to +100.2	
+1000.0	1000	VDC	+998 to 1002	

7. DC Current Calibration Check

DC Current Calibrator	DMM		
	Range	Readout Limits	Reading
00.0 μA	100 μ	−00.2 to +00.2	
+100 μA	100 μ	+99.5 to +100.5	
+1.000 mA	1 m	+.995 to +1.005	
+10.00	10 m	+9.95 to +10.05	
+100.0	100 m	+99.5 to +100.5	
+1000	1000 m	+995 to +1005	

*Except Option 39 or 39A.

Form 5–1, Performance Test Record

8. AC Voltage Calibration Check

AC Voltage Calibrator		DMM		
Voltage	Frequency	Range	Display Limits	Reading
0000 mV	500 Hz	100 m	00.0 to 00.5	
10.00 mV	500 Hz	100 m	09.7 to 10.3	
100.00 mV	500 Hz	100 m	98.8 to 101.2	
100.0 mV	5 kHz	100 m	98.8 to 101.2	
100.0 mV	50 kHz	100 m	97.8 to 102.2	
180 mV	500 Hz	100 m	178.0 to 182.0	
180 mV	50 kHz	100 m	175.8 to 184.2	
1.000 V	500 Hz	1	.988 to 1.012	
1.000 V	5 kHz	1	.988 to 1.012	
1.000 V	50 kHz	1	.978 to 1.022	
10.00 V	500 Hz	10	9.88 to 10.12	
10.00 V	50 kHz	10	9.78 to 10.22	
100.0 V	500 Hz	100	98.8 to 101.2	
100.0 V	50 kHz	100	97.8 to 102.2	
1000.0 V	500 Hz	1000	988 to 1012	
1000.0 V	50 kHz	1000	978 to 1022	

9. Ohms Calibration Check

Resistance Standard	Function	DMM		
		Range	Display Limits	Reading
0000	LOΩ	100	00.0 to 00.6	
100.00	LOΩ	100	99.7 to 100.6	
1.0000 k	LOΩ	1 K	997 to 1006	
1.0000 k	HIΩ	1 K	997 to 1006	
10.000 k	LOΩ	10 K	9.97 to 10.06	
10.000 k	HIΩ	10 K	9.97 to 10.06	
100.00 k	LOΩ	100 K	99.7 to 100.6	
100.00 k	HIΩ	100 K	99.7 to 100.6	
1.0000 M	LOΩ	1000 K	994 to 1006	
1.000 M	HIΩ	1000 K	997 to 1003	
1.000 M	HIΩ	10 M	9.94 to 10.06	

Signature *Date*

Ballantine Laboratories, Inc.
P.O. Box 97, Boonton, New Jersey 07005, U.S.A.
Telephone: 201-335-0900 TWX: 710-987-8380

SECTION 6

REPLACEABLE PARTS LIST AND CIRCUIT SCHEMATIC DIAGRAMS

The replacement parts listed are available from the vendors or from Ballantine Labs. Your local Ballantine Field Engineering Representative may also carry a stock of parts and can assist you. If pricing quotations are required for parts and or repairs your local representative will give the most rapid service or you may contact the Ballantine Factory directly:

Instrument Service Department
Ballantine Laboratories, Inc.
P.O. Box 97
90 Fanny Road
Boonton, N.J. U.S.A. 07005

When ordering replacement parts always give the following information:

a) Instrument Model number
b) Serial number
c) Ballantine Part number
d) Schematic Symbol number
e) Identification of the part

Ballantine will do its best to improve the instrument and make changes in style of components and replacement parts. Replacement parts may differ in appearance from those found in your instrument but are always equal or superior in performance. Where necessary, minor mechanical modifications may be required in the replacement of components.

Parts are generally available locally for most replacements. The parts list calls out the recommended vendors where applicable. Always use the exact part called out in the parts list or an equivalent approved by Ballantine to ensure that all performance specifications will be met.

The Manufacturer Code is taken from Federal Supply Code Cataloging Handbooks H4-1, H4-2, and H4-3. Ballantine Code is 50423.

The following parts coding are used:

CVC Capacitor, Variable, Ceramic
CEP Capacitor, Fixed, Plastic
CCD Capacitor, Ceramic, Disc
CYF Capacitor, Mylar, Foil

CMD Capacitor, Mica, Dipped
CMM Capacitor, Mica, Molded
CEA Capacitor, Electrolytic, Aluminum
CET Capacitor, Electrolytic, Tantalum

DGP Diode, General Purpose
DZG Diode, Zener, General Purpose
DRP Diode, Bridge, Power
FLT Filter
ICP Integrated Circuit

TRQ Transistor

RFF Resistor, Fixed, Film
RFC Resistor, Fixed, Composition
RFW Resistor, Fixed, Wirewound

SWC Switch

LMP Lamp

TRX Transformer

Resistors may generally be replaced by Corning Electronics (CCW) type N-55, N-60, and C-32. Allen Bradley composition resistors type EB are also used.

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
C 100	07103360A	CBM 47.0NF 1.6KV +-10%	80031	MEPCO C281/1600/A47K
C 101	07103551A	CTE 4.5PF 1.2KVJ	50423	BLI 3028A SPEC-WIRE
C 102	07103490A	CMD 560.0PF 500.0 V TCE 1%	84171	ARCO DM15ED560F03 ARCO
C 103	07103600A	CVC 10-60PF 350.0 V N750	50423	
C 104	07103500A	CMD 470.0PF 500.0 V TCE 2%	84171	ARCO DM15ED470G03 ARCO
C 105	07103540A	CMD 1.0NF 500.0 V +- 1%	84171	ARCO DM-19-E-D-1000-F-N-U
C 106	07101030A	CMD 250.0PF 500 V +-5%	84171	ELMENCO DM1525J
C 107	07103471A	CVE 1.2PF 1.2KVJ	50423	BLI 3028A SPEC.WIRE
C 108	07202510A	CMD 47.0PF 1.5KV 5%	84171	ARCO DM15-E-H-470-J-N-1
C 109	07022860A	CMD 39 PF 500 V J 5%	84171	ARCO TYPE DM-15-390-J
C 110	07103600A	CVC 10-60PF 350.0 V N750	50423	
C 300	07022600A	CMD 100 PF 500 V J 5%	84171	ARCO TYPE DM-15-101-J
C 301	07101980A	CCD 100.0NF 25.0 V NPO	56289	SPRAG C069A250M1042 OR EQ
C 401	07101980A	CCD 100.0NF 25.0 V NPO	56289	SPRAG C069A250M1042 OR EQ
C 403	07103410A	CBM 470.0NF 100.0 V +-10%	80031	MEPCO C280MCH/A470K
C 404	07101980A	CCD 100.0NF 25.0 V NPO	56289	SPRAG C069A250M1042 OR EQ
C 406	07102580A	CET 68.0UF 15.0 VK DIP TAN	56289	SPRAG 196D686X9015-LA3
C 407	07101790A	CET 22.0UF 15.0 VM	56289	SPRAGUE 196D226X0015KE3
C 408	07101790A	CET 22.0UF 15.0 VM	56289	SPRAGUE 196D226X0015KE3
C 409	07100040A	CMD 300.0PF 500.0V DM15	84171	ARCO DM-15-301J
C 410	07103410A	CBM 470.0NF 100.0 V +-10%	80031	MEPCO C280MCH/A470K
C 500	07103410A	CBM 470.0NF 100.0 V +-10%	80031	MEPCO C280MCH/A470K
C 501	07103580A	CBM 1.0UF 100.0 VK MET POL	80031	MEPCO C280MCH/A1M
C 502	07101980A	CCD 100.0NF 25.0 V NPO	56289	SPRAG C069A250M1042 OR EQ
C 503	07101980A	CCD 100.0NF 25.0 V NPO	56289	SPRAG C069A250M1042 OR EQ
C 504	07101170A	CMD 12.0PF 500.0 VJ	84171	ELMENCO DM15C120JN
C 600	07103370A	CBM 68.0NF 630.0 V +-10%	80031	MEPCO C280MCG/A68K
C 601	07103380A	CBM 33.0NF 400.0 V +-10%	80031	MEPCO C280MCF/A33K
C 602	07103390A	CBM 100.0NF 100.0 V +-10%	80031	MEPCO C280MCH/A100K
C 603	07202510A	CMD 47.0PF 1.5KV 5%	84171	ARCO DM15-E-H-470-J-N-1
C 605	07103400A	CBM 22.0NF 400.0 V +-10%	80031	MEPCO C280MCF/A22K
C 700	07101790A	CET 22.0UF 15.0 VM	56289	SPRAGUE 196D226X0015KE3
C 701	07101790A	CET 22.0UF 15.0 VM	56289	SPRAGUE 196D226X0015KE3
C 702	07101980A	CCD 100.0NF 25.0 V NPO	56289	SPRAG C069A250M1042 OR EQ
C 703	07101980A	CCD 100.0NF 25.0 V NPO	56289	SPRAG C069A250M1042 OR EQ
C 800	07103380A	CBM 33.0NF 400.0 V +-10%	80031	MEPCO C280MCF/A33K
C 801	07103380A	CBM 33.0NF 400.0 V +-10%	80031	MEPCO C280MCF/A33K
C 802	07103420A	CEA 100.0UF 6.0 V +-10%	50423	
C 803	07103060A	CEA1000.0UF 16.0 V STANDUP	50423	
C 804	07103060A	CEA1000.0UF 16.0 V STANDUP	50423	
C 805	07101980A	CCD 100.0NF 25.0 V NPO	56289	SPRAG C069A250M1042 OR EQ
C 806	07101980A	CCD 100.0NF 25.0 V NPO	56289	SPRAG C069A250M1042 OR EQ
C 807	07101980A	CCD 100.0NF 25.0 V NPO	56289	SPRAG C069A250M1042 OR EQ
C 808	07101790A	CET 22.0UF 15.0 VM	56289	SPRAGUE 196D226X0015KE3
C 900	07103060A	CEA1000.0UF 16.0 V STANDUP	50423	
C 901	07103060A	CEA1000.0UF 16.0 V STANDUP	50423	
CB 10	19100351A	CBK 2A BREAKER FAST LNG SHFT	50423	BLI
CR 200	05100630A	DRP IN5400 50 3A	04713	MOT SI
CR 201	05100630A	DRP IN5400 50 3A	04713	MOT SI
CR 202	05100630A	DRP IN5400 50 3A	04713	MOT SI
CR 203	05100630A	DRP IN5400 50 3A	04713	MOT SI
CR 300	05100350A	DZG IN758A 10 20M .4	04713	MOT SI
CR 301	05100350A	DZG IN758A 10 20M .4	04713	MOT SI
CR 302	05079200A	DGP IN4148 75 10M	07263	FCH SI D035
CR 400	05079200A	DGP IN4148 75 10M	07263	FCH SI D035
CR 401	05079200A	DGP IN4148 75 10M	07263	FCH SI D035
CR 402	05079200A	DGP IN4148 75 10M	07263	FCH SI D035
CR 403	05079200A	DGP IN4148 75 10M	07263	FCH SI D035
CR 500	05079200A	DGP IN4148 75 10M	07263	FCH SI D035
CR 601	05094680A	DGP FD300 150 375M .4	07263	FCH SI D07
CR 602	05094680A	DGP FD300 150 375M .4	07263	FCH SI D07

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
CR 800	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
CR 801	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
CR 802	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
CR 803	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
CR 804	05100320A	DZG 1N9618 10 12M .4	07263	FCH SI D07
CR 900	05100060A	DGP W04M 400 1.5A	04713	GIC
DS 750	21100160A	IND 0.4 IN COM CAT ORANGE LD	50522	MONSANTO 4640
DS 751	21100160A	IND 0.4 IN COM CAT ORANGE LD	50522	MONSANTO 4640
DS 752	21100160A	IND 0.4 IN COM CAT ORANGE LD	50522	MONSANTO 4640
DS 753	21100120A	IND 0.4 IN ORANGE +1 LED	26483	MONSANTO 4630
F 50	19100360A	FUS .125A NORMAL-BLO	75915	LITTELFUSE TYP3AG NORMBLO
J 1	31301260A	CON FLEXPRINT 20 PINS PC MT	26394	ANSLEY 609 2003
J 1A	31301270A	ADA ADAPTER FOR 31301260A	26394	ANSLEY 609-W208
J 10	31101320A	BPS 10MM GREY	50423	BLI
J 20	31101320A	BPS 10MM GREY	50423	BLI
J 30	31101330A	BPS 10MM BLACK	50423	BLI
J 50	31100000A	REC AC POWER	82389	SWITCHCRAFT
L 10	46100020A	FRB FER BD 4AMAT.047ID	02114	FERROX CUBE 56590 65/HA
L 20	46100020A	FRB FER BD 4AMAT.047ID	02114	FERROX CUBE 56590 65/HA
L 30	46100020A	FRB FER BD 4AMAT.047ID	02114	FERROX CUBE 56590 65/HA
Q 300	10100430A	TRQ 2N3904 NPN 1 40 PTO-92	04713	MOT 1 300M 40
Q 301	10100430A	TRQ 2N3904 NPN 1 40 PTO-92	04713	MOT 1 300M 40
Q 302	05100763B	DZG 2N4274 6.8V 1.5M+-10%	50423	BLI SELECT.FROM 05100763B
Q 302	05100763B	DZG 2N4274	50423	
Q 400	10101051A	TRQ SELECTED	50423	RCA 40673 SELECTED
Q 401	10094730A	TRQ 2N3906 PNP	04713	MOT 1 200M 60
Q 600	10100990A	TRQ E507	17856	SILICONIX
Q 601	05100763B	DZG 2N4274 6.8V 1.5M+-10%	50423	BLI SELECT.FROM 05100763B
Q 602	10100290A	TRQ 2N4400 NPN 1 40 PTO-92	04213	MOT 1 200M 20
Q 700	10100430A	TRQ 2N3904 NPN 1 40 PTO-92	04713	MOT 1 300M 40
Q 701	10094730A	TRQ 2N3906 PNP 1 40 PTO-92	04713	MOT 1 200M 60
Q 800	10100800A	TRQ 2N4403 PNP	04713	MOTOROLA
Q 801	10100800A	TRQ 2N4403 PNP	04713	MOTOROLA
R 100	12128670A	RFF 9.76M 2.0 W 1%	03888	PYROFILM PME 64T9 2.5KV
R 101	09100090A	RVC 250.0 K 0.5 WK +-10%	73138	HEL TYP 72PM
R 102	12128600A	RFF 88.7 K 1.0 W 1% 25PPM	16299	CGW NN650 OR EQUIV
R 103	09100020A	RVC 5.0 K 0.5 WK +-10%	73138	HEL TYP 72PM
R 104	12128610A	RFW 10.0 K 7.0 W 0.05%	50423	
R 105	12010100A	RFC 1.0 M 500.0MW J+- 5%	01121	A-B TYP EB
R 106	12010260A	RFC 100.0 K 500.0MW J+- 5%	01121	A-B TYP EB
R 107	12010480A	RFC 4.7 K 500.0MW J+- 5%	01121	A-B TYP EB
R 108	12010030A	RFC 5.1 M 500.0MW J+- 5%	01121	A-B TYP EB
R 200	12128730A	RFC 560.0 K 500.0MW	01121	A-B TYPE E-B
R 201	12128730A	RFC 560.0 K 500.0MW	01121	A-B TYPE E-B
R 300	12123890A	RFF 8.45K 500 MW F+-1%	16299	CGW RN60D 8451 F
R 301	09100050A	RVF 1.00K 0.5 WK CERMET	73138	HELIPOT 72PM
R 302	12123000A	RFF 1.0 K 500 MW F+-1%	16299	CGW RN60D 1001 F
R 303	12123890A	RFF 8.45K 500 MW F+-1%	16299	CGW RN60D 8451 F
R 304	09100050A	RVF 1.00K 0.5 WK CERMET	73138	HELIPOT 72PM
R 305	12010480A	RFC 4.7 K 500.0MW J+- 5%	01121	A-B TYP EB
R 400	12128630A	RFC 150.0 K 2.0 W 5%	01121	A-B HB
R 401	12010570A	RFC 1.0 K 500.0MWJ +- 5%	01121	A-B TYP EB
R 402	12010480A	RFC 4.7 K 500.0MW J+- 5%	01121	A-B TYP EB
R 404	12010070A	RFC 2.0 M 500.0MW J+- 5%	01121	A-B TYP EB
R 405	12123280A	RFF 1.96K 500 MW F+-1%	16299	CGW RN60D 1961 F
R 406	12123280A	RFF 1.96K 500 MW F+-1%	16299	CGW RN60D 1961 F
R 408	12122920A	RFF 909.0 500 MW F+-1%	16299	CGW RN60D 9090 F
R 409	09100040A	RVF 100.0 0.5 W M	73138	HEL TYP 72PM
R 410	12123720A	RFF 5.62K 500 MW F+-1%	16299	CGW RN60D 5621 F

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
R 411	12089580A	RCF 240.0 K 500.0MW J+- 5%	01121	A-B TYP EB
R 500	12089580A	RCF 240.0 K 500.0MW J+- 5%	01121	A-B TYP EB
R 501	12123280A	RFF 1.96K 500 MW F+-1%	16299	CGW RN60D 1961 F
R 502	12010720A	RFC 39.0 500.0MW J+- 5%	01121	A-B TYP EB
R 503	12010100A	RFC 1.0 M 500.0MW J+- 5%	01121	A-B TYP EB
R 504	12080210A	RFC 1.2 M 250.0MW J+- 5%	01121	A-B TYP CB
R 505	12010500A	RFC 3.9 K 500.0MW J+- 5%	01121	A-B TYP EB
R 506	09100030A	RVC 100.0 K 0.5 WK +-10%	73138	HEL TYP 72PM
R 507	12124520A	RFF 34.8 K 500 MW F+-1%	16299	CGW RN60D 3482 F
R 600	12128620A	RFC 560.0 K 2.0 W 5%	01121	A-B HB
R 601	12128730A	RFC 560.0 K 500.0MW	01121	A-B TYPE E-B
R 602	12010810A	RFC 27.0 K 500.MW J+- 5%	01121	A-B TYP EB
R 603	12128730A	RFC 560.0 K 500.0MW	01121	A-B TYPE E-B
R 604	09101460A	RVF 25.0 K 500.0MW TRIMPOT	73138	HELIPOT 72PM
R 605	09101460A	RVF 25.0 K 500.0MW TRIMPOT	73138	HELIPOT 72PM
R 606	12011380A	RFC 1.8 500.0MW K+-10%	01121	A-B TYP EB
R 607	09100020A	RVC 5.0 K 0.5 WK +-10%	73138	HEL TYP 72PM
R 608	09100010A	RVC 500.0 0.5 W K	73138	HEL TYP 72PM
R 610	12010810A	RFC 27.0 K 500.MW J+- 5%	01121	A-B TYP EB
R 700	12010480A	RFC 4.7 K 500.0MW J+- 5%	01121	A-B TYP EB
R 701	12010480A	RFC 4.7 K 500.0MW J+- 5%	01121	A-B TYP EB
R 702	12010480A	RFC 4.7 K 500.0MW J+- 5%	01121	A-B TYP EB
R 703	12010670A	RFC 150.0 500.0MW J+- 5%	01121	A-B TYP EB
R 704	12010670A	RFC 150.0 500.0MW J+- 5%	01121	A-B TYP EB
R 705	12011120A	RFC 470.0 500.0MW J+- 5%	01121	A-B TYP EB
R 706	12011300A	RFC 75.0 500.0MW J+- 5%	01121	A-B TYP EB
R 800	12010440A	RFC 10.0 K 500.0MW J+- 5%	01121	A-B TYP EB
R 801	09101070A	RVF 200.0 250.0MW K CER	73138	HEL TYPE 72PM-200
R 802	12089550A	RFC 360.0 500.0MW J+- 5%	01121	A-B TYP EB
R 900	12124640A	RFF 46.4 K 500 MW F+-1%	16299	CGW RN60D 4642 F
R 901	12123720A	RFF 5.62K 500 MW F+-1%	16299	CGW RN60D 5621 F
R 903*	12129350A	RFC 47 M 1.0 W K+-10%	01121	A-B TYPE GB
R 904*	12129340A	RFC 3.3 M 500 MW J+-5%	01121	A-B TYPE EB
RN 200	13100021A	RNW 3028A SHUNT RES,14DIP	50423	BLI
RN 600	13100001A	RNF 8 RES 14 DIP HI VALUE	50423	
RN 700	13100030A	RNF 8 RES,150 R,2%	80053	BECKMAN 898-3-R150
RN 800	13100011A	RNF 8 RES 14 DIP LO VALUE	50423	
S 1	25101241F	SWC 3028A RMS 6PB RANGE	50423	
S 2	25101241F	SWC 3028A RMS 6PB RANGE	50423	
S 3	25101241F	SWC 3028A RMS 6PB RANGE	50423	
S 4	25101241F	SWC 3028A RMS 6PB RANGE	50423	
S 5	25101241F	SWC 3028A RMS 6PB RANGE	50423	
S 6	25101241F	SWC 3028A RMS 6PB RANGE	50423	
S 7	25101251F	SWC 3028A RMS 6PB FUNCTION	50423	
S 8	25101251F	SWC 3028A RMS 6PB FUNCTION	50423	
S 9	25101251F	SWC 3028A RMS 6PB FUNCTION	50423	
S 10	25101251F	SWC 3028A RMS 6PB FUNCTION	50423	
S 11	25101251F	SWC 3028A RMS 6PB FUNCTION	50423	
S 12	25101251F	SWC 3028A RMS 6PB FUNCTION	50423	
T 800	20100291B	TRX 3028A DC/DC CONVERTER	50423	
T 900	20100311Q	TRX 3028A-39 POWER TRANS	50423	BLI REV 120 VOLT
T 900	20100301Q	TRX POWER (FOR OPTION 06)	50423	BLI
U 300	24101000A	ICP CA3130T OP AMP TO-5	86684	RCA
U 400	24101100A	ICP LM318 FAST OP AMP	27014	NATL SEMICON
U 500	24101000A	ICP CA3130T OP AMP TO-5	86684	RCA
U 600	24100931A	TCP DVM ANALOG 0.03%	17856	SILICONIX LD111 MODIFIED
U 700	24100941A	ICP DVM DIGITAL 3 1/2 DIGIT	17856	SILICONIX LD110 MODIFIED
U 701	24100840A	ICP SN7416N HEX INV 15V COLL	33809	TI OR EQUIV
U 702	24101090A	ICP MC 14511 7 SEGMENT DRIVE	04713	MOTOROLA OR EQUIV
U 900	24100010A	TCD UA7805	07263	FAIRCHILD

* Optional; used with high-voltage probes for safety purposes.

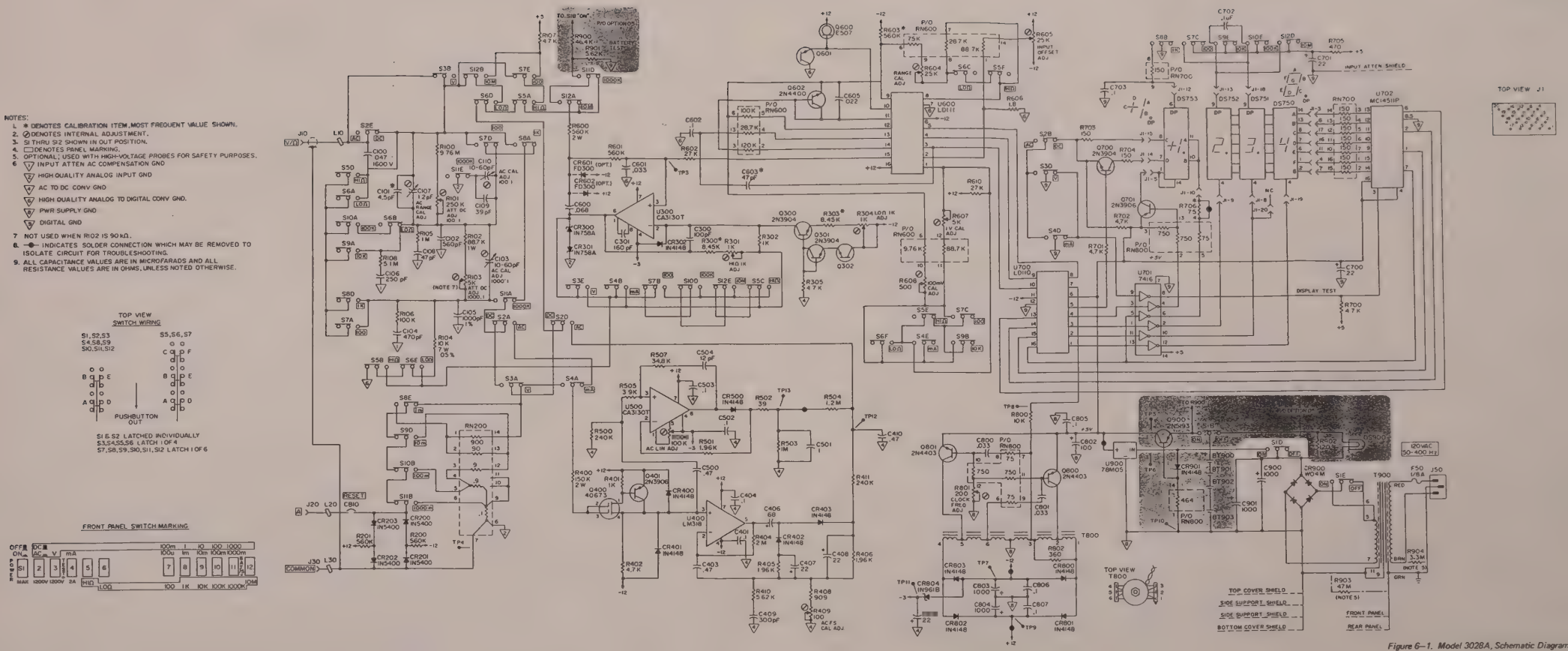


Figure 6–1. Model 3028A, Schematic Diagram

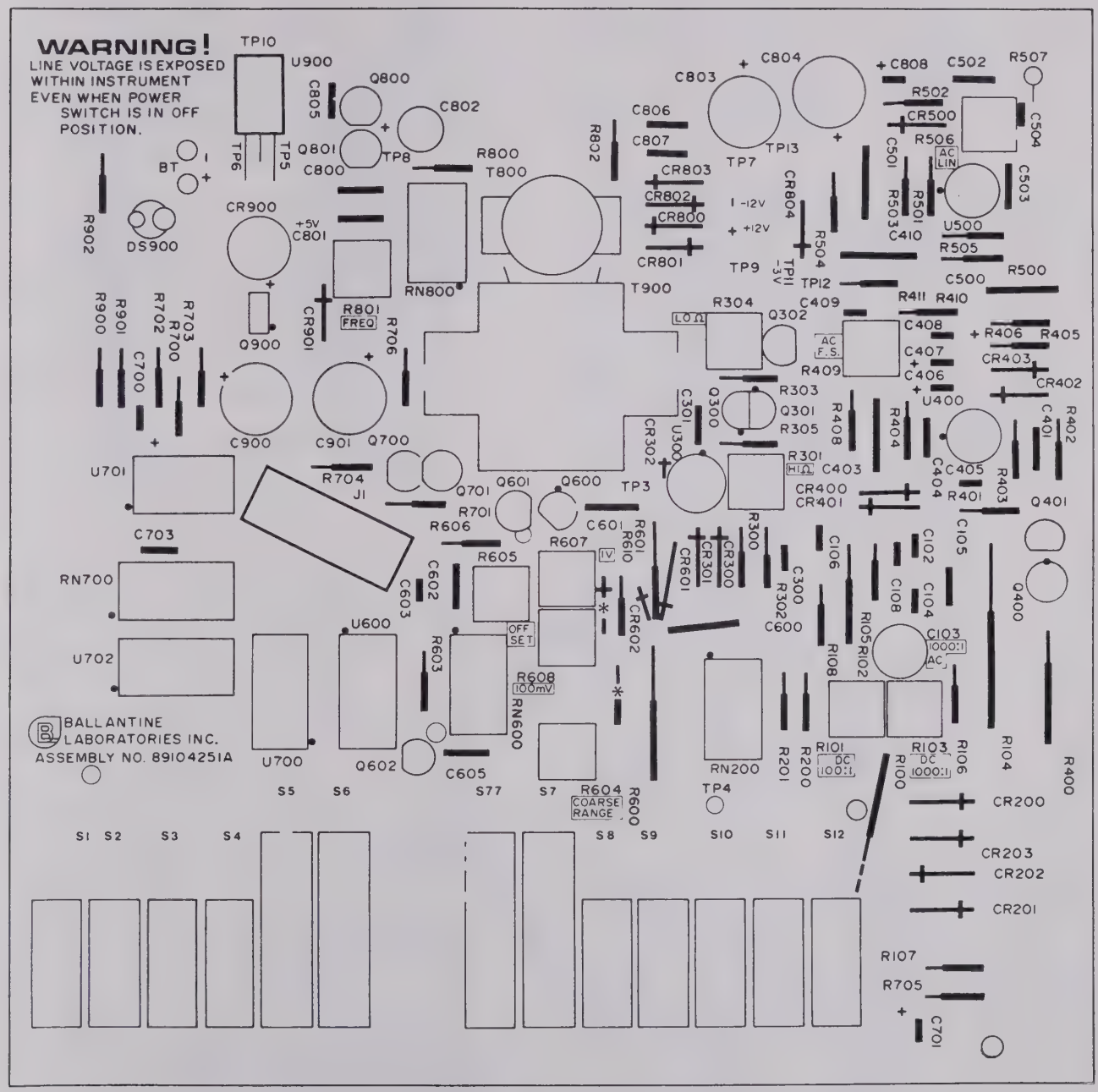
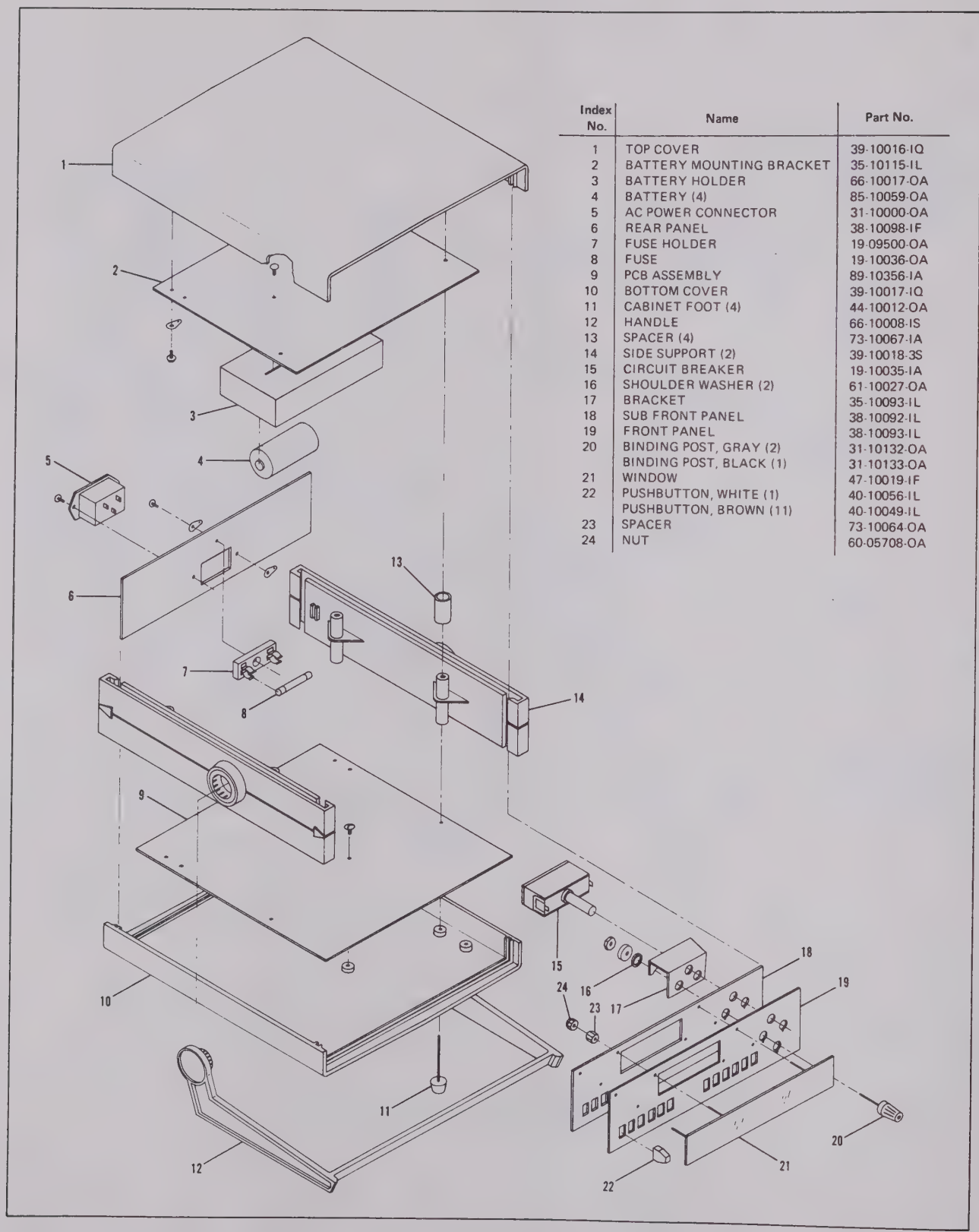


Figure 6–2. Model 3028A, Parts Location Diagram



Index No.	Name	Part No.
1	TOP COVER	39-10016-IQ
2	BATTERY MOUNTING BRACKET	35-10115-IL
3	BATTERY HOLDER	66-10017-OA
4	BATTERY (4)	85-10059-OA
5	AC POWER CONNECTOR	31-10000-OA
6	REAR PANEL	38-10098-IF
7	FUSE HOLDER	19-09500-OA
8	FUSE	19-10036-OA
9	PCB ASSEMBLY	89-10356-IA
10	BOTTOM COVER	39-10017-IQ
11	CABINET FOOT (4)	44-10012-OA
12	HANDLE	66-10008-IS
13	SPACER (4)	73-10067-IA
14	SIDE SUPPORT (2)	39-10018-3S
15	CIRCUIT BREAKER	19-10035-IA
16	SHOULDER WASHER (2)	61-10027-OA
17	BRACKET	35-10093-IL
18	SUB FRONT PANEL	38-10092-IL
19	FRONT PANEL	38-10093-IL
20	BINDING POST, GRAY (2)	31-10132-OA
	BINDING POST, BLACK (1)	31-10133-OA
21	WINDOW	47-10019-IF
22	PUSHBUTTON, WHITE (1)	40-10056-IL
	PUSHBUTTON, BROWN (11)	40-10049-IL
23	SPACER	73-10064-OA
24	NUT	60-05708-OA

Figure 6–3. Model 3028A, Case Assembly, Exploded View

SECTION 7
OPTIONS AND ACCESSORIES

7–1. INTRODUCTION.

7–2. This section contains information for the options and accessories which can be used with the Model 3028A Digital Multimeter. Each option and accessory is described individually. Where applicable, field installation procedures, operating and maintenance instructions, a replaceable parts list, and a schematic diagram are included.

7–3. PARALLEL BCD PRINTER OUTPUT, OPTION 01.

7–4. General. The BCD output option provides digital measurement information in parallel BCD format to a rear-panel connector for use with digital printers, systems, limit controllers, and other remote applications.

7–5. Specifications.

Type: Serial to parallel converter.

Logic: Positive true.

Form: Four-line BCD 1-2-4-8.
TTL compatible. Buffered for fan-out of two.
"1" = +3.5 V dc to 5.7 V dc.
"0" = 0 to 0.4 V dc.

Data Output Update Command: By "0" state of negative-going input pulse 10 μs, or contact closure to digital common. New measurements made after pulse will be displayed but will not appear at BCD outputs. Maximum allowable update command rate, three per second.

Continuous Data Output Update Command: By holding "0" state, the BCD output is updated at an internal trigger rate of typically four per second.

Busy Flag (Printer Inhibit): "1" state at Busy Flag output signifies BCD output in process of updating. During this interval, all Data Update command pulses from printer are ignored. "0" state signifies not Busy. Busy Flag internally modifiable to Ready.

Data Output "Pullup" Voltage: Normally "1" state (+5 V dc). Internal pullup through 15 kΩ. Modifiable to +12 V.

7–6. Operation.

7–7. *Input/Output Data.* The input/output data available at the rear-panel connector J1200 is listed in Table 7–1. The pin assignments and the logic level requirements are also listed.

7–8. *Data Update Input.* The BCD output may be updated by either a Data Update pulse or a Continuous Update command. This feature operates as the conventional "inhibit" signal. The Data Update pulse at pin 23 must be a negative-going pulse having a width greater than 10 μs. Measurement data accumulated after a Data Update pulse is received will not appear at the BCD output connector J1200, but the new data will be displayed. The maximum allowable rate of data update is three per second. The Continuous Update command at pin 24, when held, will cause the BCD output to be updated at the DMM display, multiplex refresh rate of approximately four per second.

7–9. *Busy Flag Output.* The time period of actual updating of the BCD output serial-to-parallel converter is signified by a Busy Flag output at pin 22 of the BCD output connector, J1200. During this period all external update pulses are locked out and therefore ignored. A signal low shows not Busy. This feature operates as the conventional "print" command. A simple modification on the BCD output printed circuit board assembly permits the Busy Flag logic to be inverted and thereby used as a Ready Flag. A signal high on pin 22 will then show that the BCD output is ready for update. A signal low indicates not Ready since the serial-to-parallel converter is being updated by the counter. To modify the Busy Flag, proceed as follows:

1. Disconnect the power cord.
2. Remove the top cover of the instrument case. Refer to paragraph 5–33.
3. Locate S1200 (a wire link switch near U1206) on the BCD output assembly.
4. Refer to the BCD schematic, Figure 7–1, and remove jumper wire S1200-1, 3.
5. Install the jumper wire as S1200-1, 2 to provide a Ready Flag.
6. Replace the top cover and reconnect the power cord.

7–10. *Data Output Pullup Voltage.* The BCD output data lines are normally pulled up through 15 kΩ resistors to the +5 V dc supply of the counter. A simple jumper modification at S1201 on the BCD output assembly permits an external pullup voltage (+5.7 V dc maximum) to be applied at pin 25 of the BCD output connector, J1200. To modify the unit to incorporate the external pullup feature, proceed as follows:

1. Disconnect the power cord.
2. Remove the top cover of the instrument case. Refer to paragraph 5–33.
3. Locate S1202 (a wire link switch) on the BCD output assembly.
4. Refer to the BCD schematic, Figure 7–1, and remove jumper wire S1201-4, 5 to disconnect the referral +5-volt supply.

TABLE 7–1. DIGITAL INPUT/OUTPUT DATA AT CONNECTOR J1200

	Signal	Signal Logic		Logic Level	
		High	Low	"1"	"0"
1	Least Significant Digit	1	0	4.3 V to 5.7 V	0 to +0.4 V
2		2	0		
26		4	0		
27		8	0		
3	2nd Digit from LSD	1	0		
4		2	0		
28		4	0		
29		8	0		
5	3rd Digit from LSD	1	0		
6		2	0		
30		4	0		
30		8	0		
7	4th Digit from LSD	1	0		
8		2	0		
32		4	0		
33		8	0		
19	Decimal Point 1 (right)	On	–		
44	Decimal point 2	On	–		
45	Decimal point 3	On	–		
20	Circuit ground and Logic COMMON				
22	Busy Flag (Output)	Busy	Not Busy		
23	Data Update Pulse (Input)	Update	(pulse)	Open or +5 V dc	0 to +0.4 V dc or contact closure to logic COMMON
24	Continuous Update (Input)	Update			
48	Overrange	–	Overrange		
25	External Pull Up (+12V)	–	–		
47	+5 Volt Reference (1 mA Max)				
50	Case ground (earth)				

5. Install the jumper wire from S1201-4 to J1200-25 to provide the external pullup voltage connection. Carefully solder the wire in place.

6. Replace the top cover and reconnect the power cord.

7–11. *BCD Output Cable.* A six-foot long BCD output cable with mating 50-pin Blue Ribbon connectors (Ballantine Model 12253A) is available as an option.

7–12. Theory of Operation. The BCD printer output option is basically a serial-to-parallel converter with associated control circuitry. It processes the serial output data from U700 in the 3028A into parallel BCD format. Four Type D MOS flip-flops in U1201, U1202, U1203, and U1204 are the storage registers which convert digit strobes D1, D2, D3, and D4; sequent strobes B1, B2, B3, and B4; and the polarity sign data. AND gates in U1204 control the update of the storage registers. A schematic diagram is shown in Figure 7–1.

7–13. Update may be continuous at the multiplexing rate of the 3028A or commanded by pulsing the data update line. Flip-flops in U1206 store this information and provide coincidence signals to the AND gates of U1205. New data is loaded into the storage register when the clock pulse is synchronized with the digit strobes.

7–14. "D" flip-flops in U1200, U1201, U1202, U1203, and U1204 provide buffered output to drive several TTL loads. Decimal points and the polarity sign are buffered by hex inverter U1210.

7–15. The Busy Flag (or Ready Flag) output signal is provided by U1206 to indicate the state of readiness of the information in the storage registers. The Busy Flag drops to "0" indicating the completion of the data update sequence.

7–16. U1209 is a four-input coincidence detector which senses the simultaneous existence of all four digit strobes. This is the "flashing" overrange signal of the 3028A. The output of U1209 is processed by flip-flops in U1208 which holds the overrange data available at J1200.

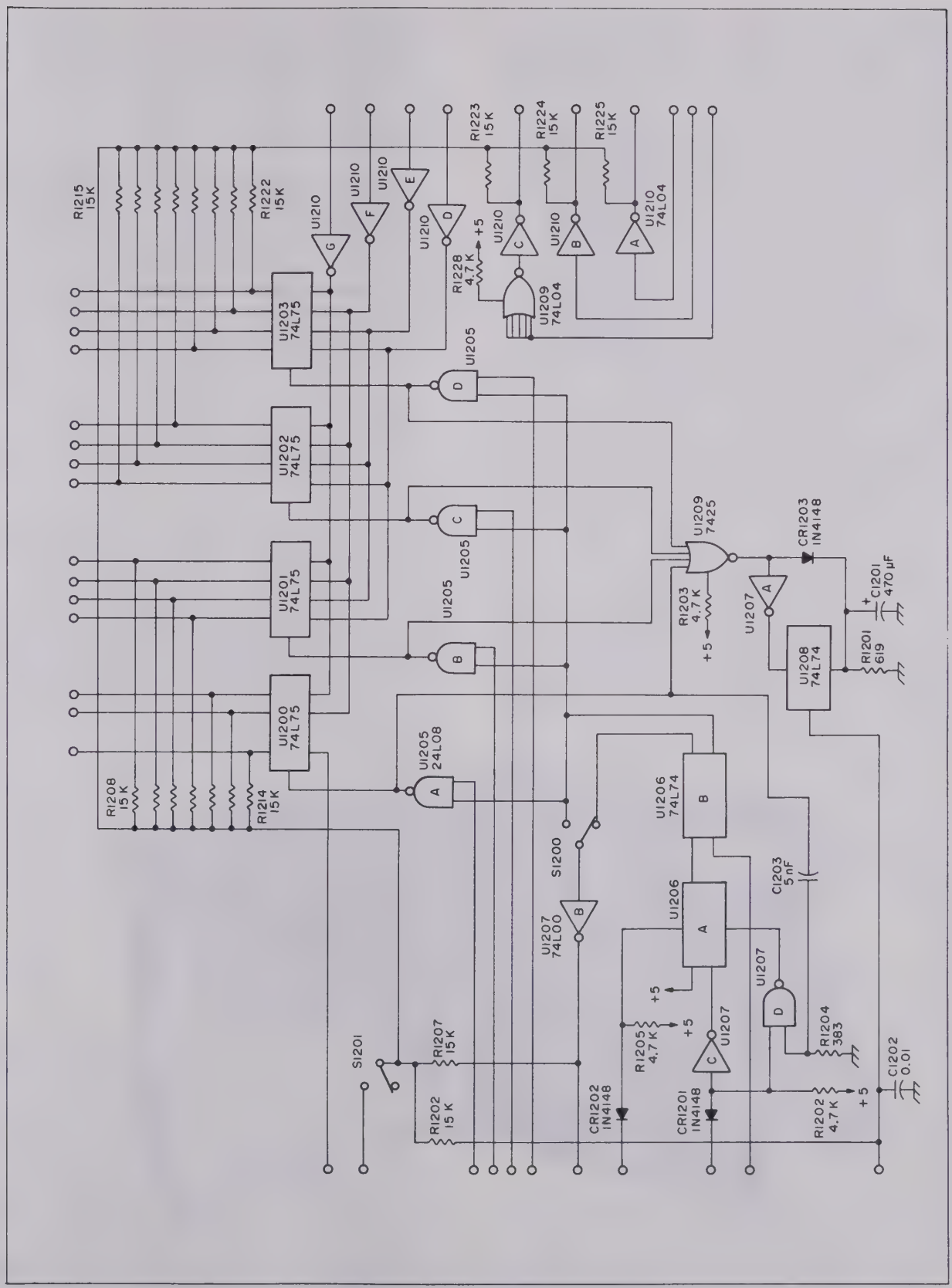


Figure 7–1. BCD Schematic Diagram.

7–17. Parts List.

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
C 1201	071009103A	CEA 470.0UF 6.3 V UPPC MNT		STETNER TRUSH ERO EK67076
C 1202	071C2340A	CCR 10. NF 100. VM	56289	SPRAGUE TG-S10 OR EQUAL
C 1203	070254003A	CCD 5 NF +0-20%	72982	ERIE TYPE EGP Z5U-851
CR 1201	051004903A	DGP IN4148 100 10M	01295	TI SI 0035 4 5 JAN
CR 1202	051004904A	DGP IN4148 100 10M	01295	TI SI 0035 4 5 JAN
CR 1203	051004903A	DGP IN4148 100 10M	01295	TI SI 0035 4 5 JAN
R 1201	121277604A	RFF 619.0 500 MW F+-1%	16299	CGW RN60D 6190 F
R 1202	121241704A	RFF 15.0 K 500 MW F+-1%	16299	CGW RN60D 1502 F
R 1203	121236404A	RFF 4.64K 500 MW F+-1%	16299	CGW RN60D 4641 F
R 1204	121225604A	RFF 383.0 500 MW F+-1%	16299	CGW RN60D 3830 F
R 1205	121236404A	RFF 4.64K 500 MW F+-1%	16299	CGW RN60D 4641 F
R 1206	121236404A	RFF 4.64K 500 MW F+-1%	16299	CGW RN60D 4641 F
R 1208	121241704A	RFF 15.0 K 500 MW F+-1%	16299	CGW RN60D 1502 F
R 1209	121241704A	RFF 15.0 K 500 MW F+-1%	16299	CGW RN60D 1502 F
R 1210	121241704A	RFF 15.0 K 500 MW F+-1%	16299	CGW RN60D 1502 F
R 1211	121241704A	RFF 15.0 K 500 MW F+-1%	16299	CGW RN60D 1502 F
R 1212	121241704A	RFF 15.0 K 500 MW F+-1%	16299	CGW RN60D 1502 F
R 1213	121241704A	RFF 15.0 K 500 MW F+-1%	16299	CGW RN60D 1502 F
R 1214	121241704A	RFF 15.0 K 500 MW F+-1%	16299	CGW RN60D 1502 F
R 1215	121241704A	RFF 15.0 K 500 MW F+-1%	16299	CGW RN60D 1502 F
R 1216	121241704A	RFF 15.0 K 500 MW F+-1%	16299	CGW RN60D 1502 F
R 1217	121241704A	RFF 15.0 K 500 MW F+-1%	16299	CGW RN60D 1502 F
R 1218	121241704A	RFF 15.0 K 500 MW F+-1%	16299	CGW RN60D 1502 F
R 1219	121241704A	RFF 15.0 K 500 MW F+-1%	16299	CGW RN60D 1502 F
R 1220	121241704A	RFF 15.0 K 500 MW F+-1%	16299	CGW RN60D 1502 F
R 1221	121241704A	RFF 15.0 K 500 MW F+-1%	16299	CGW RN60D 1502 F
R 1222	121241704A	RFF 15.0 K 500 MW F+-1%	16299	CGW RN60D 1502 F
R 1223	121241704A	RFF 15.0 K 500 MW F+-1%	16299	CGW RN60D 1502 F
R 1224	121241704A	RFF 15.0 K 500 MW F+-1%	16299	CGW RN60D 1502 F
R 1225	121241704A	RFF 15.0 K 500 MW F+-1%	16299	CGW RN60D 1502 F
R 1226	121241704A	RFF 15.0 K 500 MW F+-1%	16299	CGW RN60D 1502 F
R 1227	121241704A	RFF 15.0 K 500 MW F+-1%	16299	CGW RN60D 1502 F
R 1228	121236404A	RFF 4.64K 500 MW F+-1%	16299	CGW RN60D 4641 F
U 1200	241014104A	ICP 74LS75 QUAD LATCH 16 DIP	01295	TI
U 1201	241014104A	ICP 74LS75 QUAD LATCH 16 DIP	01295	TI
U 1202	241014104A	ICP 74LS75 QUAD LATCH 16 DIP	01295	TI
U 1204	241014104A	ICP 74LS75 QUAD LATCH 16 DIP	01295	TI
U 1205	241014404A	ICP 74LS08 QUAD AND 14 DIP	01295	TI
U 1206	241014304A	ICP 74LS74 D FIFL 14 DIP	01295	TI
U 1207	241014504A	ICP 74LS00 QUAD NAND 14 DIP	01295	TI
U 1208	241014304A	ICP 74LS74 D FIFL 14 DIP	01295	TI
U 1209	241014604A	ICP 74S260 DUAL NOR 14 DIP	01295	TI
U 1210	241014204A	ICP 74LS04 HEX INV 14 DIP	01295	TI

7–18. INTERNAL RECHARGEABLE BATTERY, OPTION 05.

7–19. General. Option 05 equips the Model 3028A with four rechargeable nickel-cadmium batteries, installed as shown in Figure 7–2, which can be used in place of ac power to operate the instrument. The optional battery connections and the charger circuit are shown in Figure 6–1. The batteries are recharged by setting the POWER switch S1 to OFF and connecting the ac power to the instrument.

7–20. Specifications.

Continuous Operation: 5 hours (20°C to 30°C)

Charge Time: 16 hours (15°C to 35°C)

Battery Life: 350 to 500 charge-discharge cycles

Battery Type: Four NiCad "C" cells

7–21. Operation. When the batteries are fully charged, the Model 3028A may be disconnected from the ac power line and operated for more than 5 hours. The battery-charge condition may be checked by disconnecting the ac power and pushing in the POWER (S1), V (S3), 1000 (S11), and 10M (S12) pushbuttons. A display reading greater than 500 indicates that the batteries are charged. Fully charged batteries will indicate above 535.

Note

It is recommended that NiCad batteries be recharged at least every 90 days and that they be stored where the temperature is below +30°C (+86°F).

For additional information and the theory of operation, refer to paragraphs 3–9, 3–10, 4–50, 4–51, and 4–52.

7–22. Installation. Battery Option 05 is easily installed in the field. Remove the covers of the instrument (refer to paragraph 5–33). Attach and secure the battery holder and the mounting plate to the underside of the top cover with the screws supplied; install the terminal lug under the right screw. Solder the blue lead to the terminal lug and to the

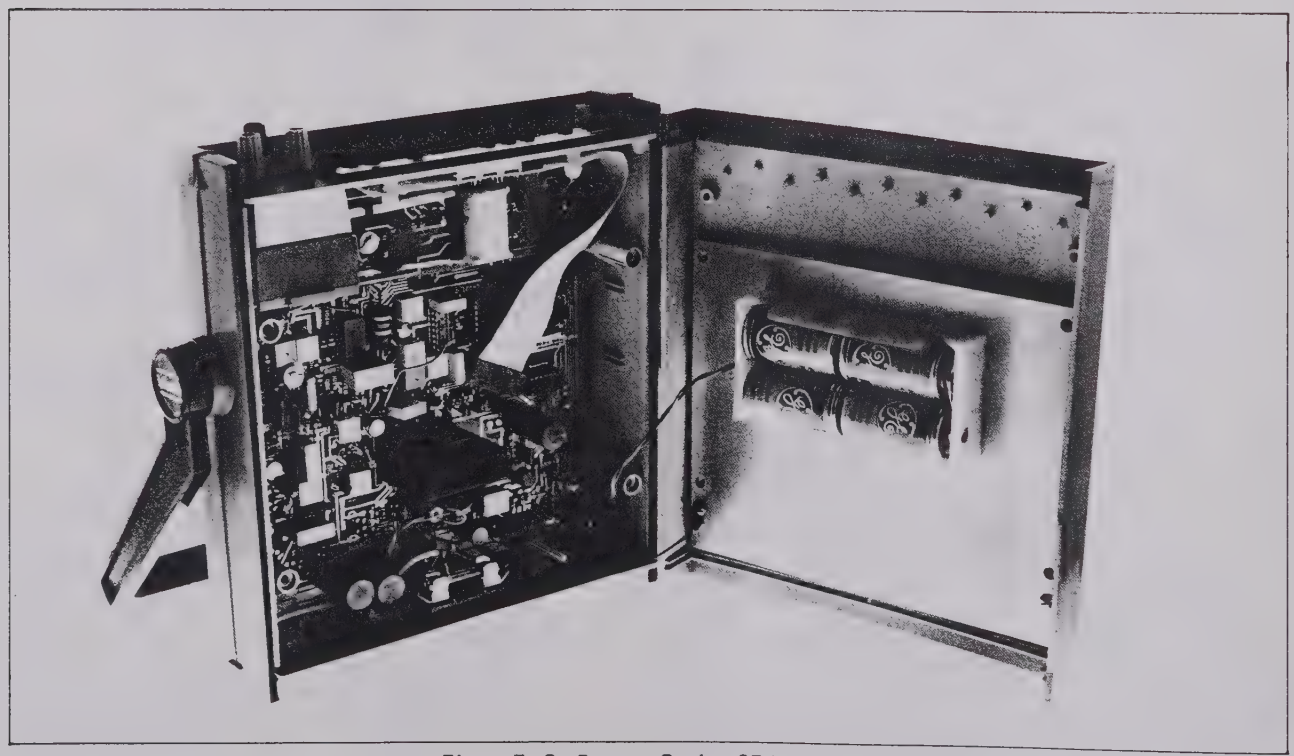


Figure 7–2. Battery Option 05 Installed.

instrument ground. Solder the battery red lead to the + terminal and the black lead to the – terminal, located at the rear left corner of the main printed wiring assembly. Install and solder lamp DS900 and resistor R902 in the holes provided in the printed wiring assembly (just to the left of the + and – terminals). Replace F50 with a 1/8-ampere, slow-blow fuse.

7–23. With the ac power cord connected, but with the POWER switch OFF, allow the batteries to charge for 16 hours. Note that DS900 lights. After the batteries are charged, check the battery-power operation of the instrument. Check the battery charge as instructed in paragraph 7–21. Replace the top and bottom covers.

7–24. Battery Replacement. Remove the top cover of the instrument (refer to paragraph 5–33). Remove the old batteries. Note the polarity markings in the holder and install four new batteries (Battery Kit P/N 89-10422-1A). Check the battery charge as described in paragraph 7–21 and recharge if necessary. Check the charging mode by noting that DS900 lights. Replace cover and attaching hardware.

7–25. Parts List.

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
BT 903	85100590A	BNC C NICK-CAD 1.5AH	09823	GOULD
BT 901	85100590A	BNC C NICK-CAD 1.5AH	09823	GOULD
BT 902	85100590A	BNC C NICK-CAD 1.5AH	09823	GOULD
BT 903	85100590A	BNC C NICK-CAD 1.5AH	09823	GOULD
CR 901	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
DS 900	1610023 0A	LMP CM-12 6.3V 150MA 91-PIN	71744	CHICAGO MINIATURE CM-12
Q 903	10100970A	TRO 2N5193 PNP 1 40 87703	04713	MOT 40 ZM 10
R 902	12019830A	RFC 120.3 500.3MW J+- 5%	01121	A-B TYP EB

7–26. UNIVERSAL AC POWER VOLTAGE, OPTION 06.

7–27. General. The standard Model 3028A is supplied for operation with nominal 120-volt, 48- to 440-Hz ac power. Option 06 provides a universal power transformer (P/N 20-10030-1) with an IEC multi-tap primary so that the 3028A may be operated with other standard ac power sources.

7–28. Specifications. The multi-tap primary of the transformer supplied with Option 06 may be wired for any one of the ac voltages listed in the following table; the subordinate option numbers are included for identification.

Option	Nominal	Range	Frequency
060	100 V	86 to 108 V	48 to 440 Hz
061	120 V	103 to 130 V	48 to 440 Hz
062	220 V	196 to 245 V	48 to 440 Hz
063	240 V	208 to 260 V	48 to 440 Hz

7–29. Installation. Check that the rear panel does not specify the operating line voltage required. Remove the top cover (refer to paragraph 5–33). Check that the power transformer T900 has only three wire leads and is marked 20-10031-1. Remove the bottom cover. Use a 35-watt soldering iron and a solder sipper to remove the solder from the retaining tabs of T900 and from the six terminals. Remove the transformer and replace it with the universal power transformer P/N 20-10030-1, making sure that the five wire leads are toward the rear panel. Carefully fold over the transformer retaining tabs. Solder the six terminals and the tabs with 60/40 rosin core solder. Clean off all flux residue.

7–30. Connections for Transformer Primary. The power transformer primary connections for the different ac input voltages specified in paragraph 7–28 are shown in Figure 7–3.

7–31. Installation Precautions. Be sure to solder all connections carefully. Twist all wires tightly together. Carefully tape exposed joined leads with electrical tape and seal with plastic shrink tubing so that no wiring is exposed. Dress all wires away from components and circuit ground on the printed wiring assembly board or top cover.

7–32. After all modification wiring has been completed, connect the 3028A to a line Variac, or similar device, which is set to zero output. Slowly increase the voltage to the 3028A and observe that it functions properly. If desired, check the unregulated +5 volts dc at TP5 to check that approximately 10 volts appears at nominal ac line voltage.

7–33. Reassemble the instrument case and mark the line voltage on the adhesive label provided for that purpose. Apply the label over the unused line voltage markings. On rear panels which list a choice of voltages, check-mark the wired voltage and eliminate the previous marking with tape or a dab of paint.

7–34. DIGITAL DISPLAY WITH ANALOG METER, OPTION 20.

7–35. General. Option 20 provides the 3028A with an analog meter in addition to the digital display. The meter operates on all ranges and functions. It provides a 0 to 2 linear scale and a –20 dB to +6 dB scale which tracks the digital indication. Zero dB measurements are in dBV referenced to a digital indication of 1000 and dBm measurements refer to 1 milliwatt into 1000 ohms. The meter indicates the absolute value of input to the multimeter on all voltage and current ranges and is used for alignment and null applications. Ohmmeter operation of the meter is not calibrated and is intended only for maximum and minimum indications.

7–36. Specifications.

Electrical: Same as basic 3028A

Meter Accuracy: ±5% full scale from 15°C to 35°C

Temperature Coefficient: –10°C to 15°C and 35°C to 55°C ± (0.25% full scale/°C)

Meter Scale: Length, 20 mm (0.75 inch)
Voltage scale, linear 0 to 2
dB scale, logarithmic, 26 dB range, marked –20 to +6, 0 dB referenced to 1 mW into 1000 ohms.

Meter Type: Edge mount, 2 mA moving magnet, shielded movement

7–37. Operation. No special instructions are required for the operation of the analog meter; the basic operating instructions for the 3028A are applicable.

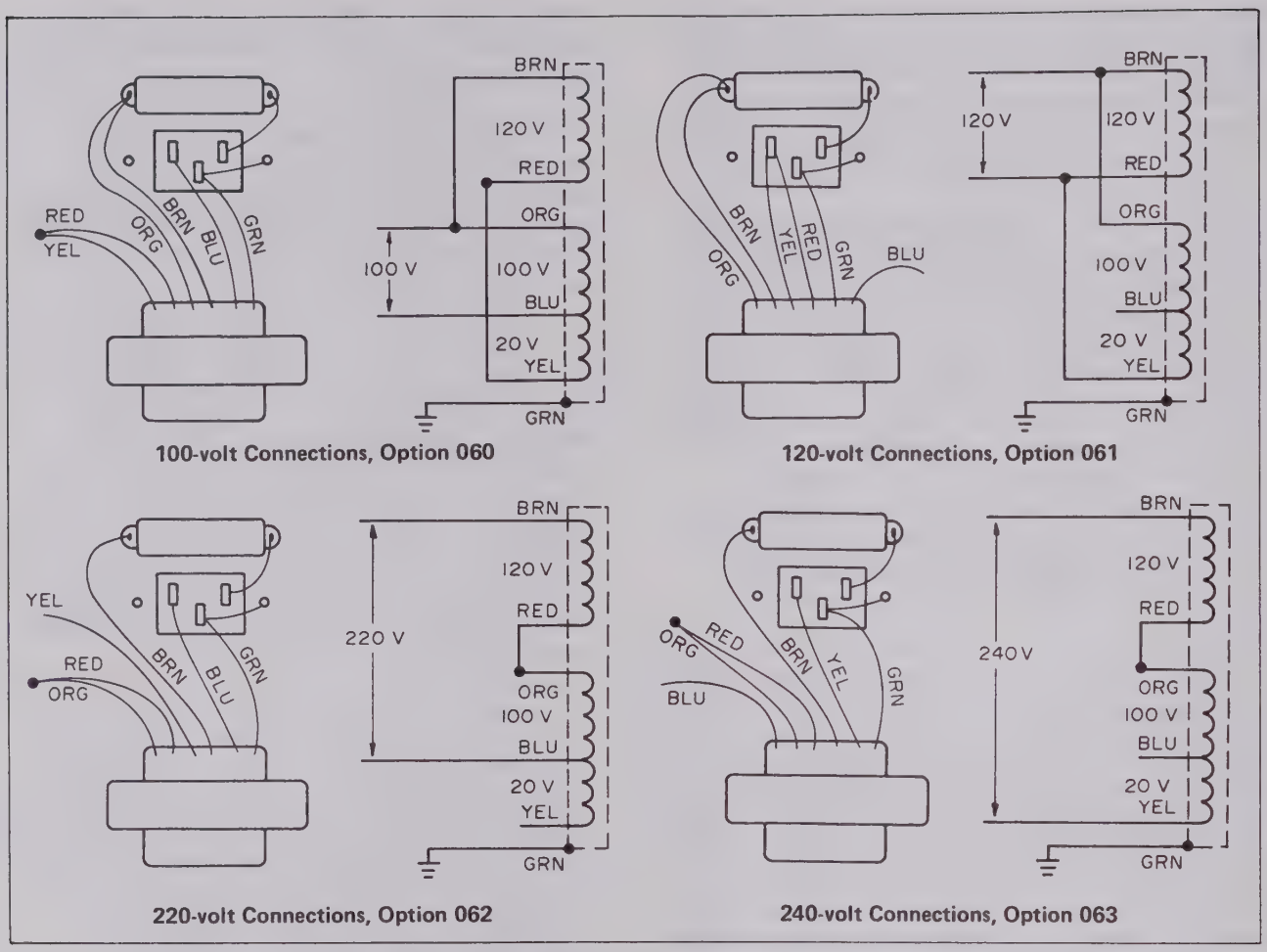


Figure 7–3. Power Transformer Primary Connections.

The dB scale of the meter is calibrated in dB. For dBm measurements, zero dBm is equivalent to 1 milliwatt dissipated by a 1000-ohm load. A reading in dB may be converted to dBm by using the impedance correction graph of Figure 7–4. For example, to convert a +6 reading across 50 ohms to dBm, locate the 50-ohm load-impedance line on the left side of the graph. Follow this line to the heavy black line and read the meter correction in dBm at the intersection point. The correction is +13 dBm and the corrected reading is +19 dBm. This example refers to voltage readings on the 1-volt range. The 3028A uses decade attenuators so the 20-dB steps are applicable as follows:

1000 V	Add +60 dB
100 V	Add +40 dB
10 V	Add +20 dB
1 V	Add +0 dB
100 mV	Subtract 20 dB

To obtain the actual dB measurement, add or subtract the dB-attenuator step to the dB reading on the meter.

7–38. Circuit Description. U3000 is a gain-of-one impedance converter which is connected to the basic 100 mV range integrator of the A to D converter. The output of U3000 drives the drain of FET Q3000. The gate of Q3000 is driven by the collector output of Q3001. This PNP is emitter-driven from the measure-zero signal of the A/D converter. The zero interval is near circuit ground and the measure interval voltage is at approximately 4 volts. Q3000 therefore conducts only during the measure interval and acts as a synchronous detector. Q3001 is an absolute-value detector operational amplifier. The meter is included in the negative feedback loop and is tied through a diode bridge so that positive or negative inputs to U3001 provide a positive signal. R3001 adjusts the meter zero through control of the input offset and R3008 acts as a full-scale meter calibration adjustment.

7–39. Calibration.

a. With power off, check that the meter pointer lies over the zero mark on the upper (0-1-2) scale. If not, carefully move the meter's mechanical zero-adjust lever located at the top rear of the meter case, until the pointer is on the

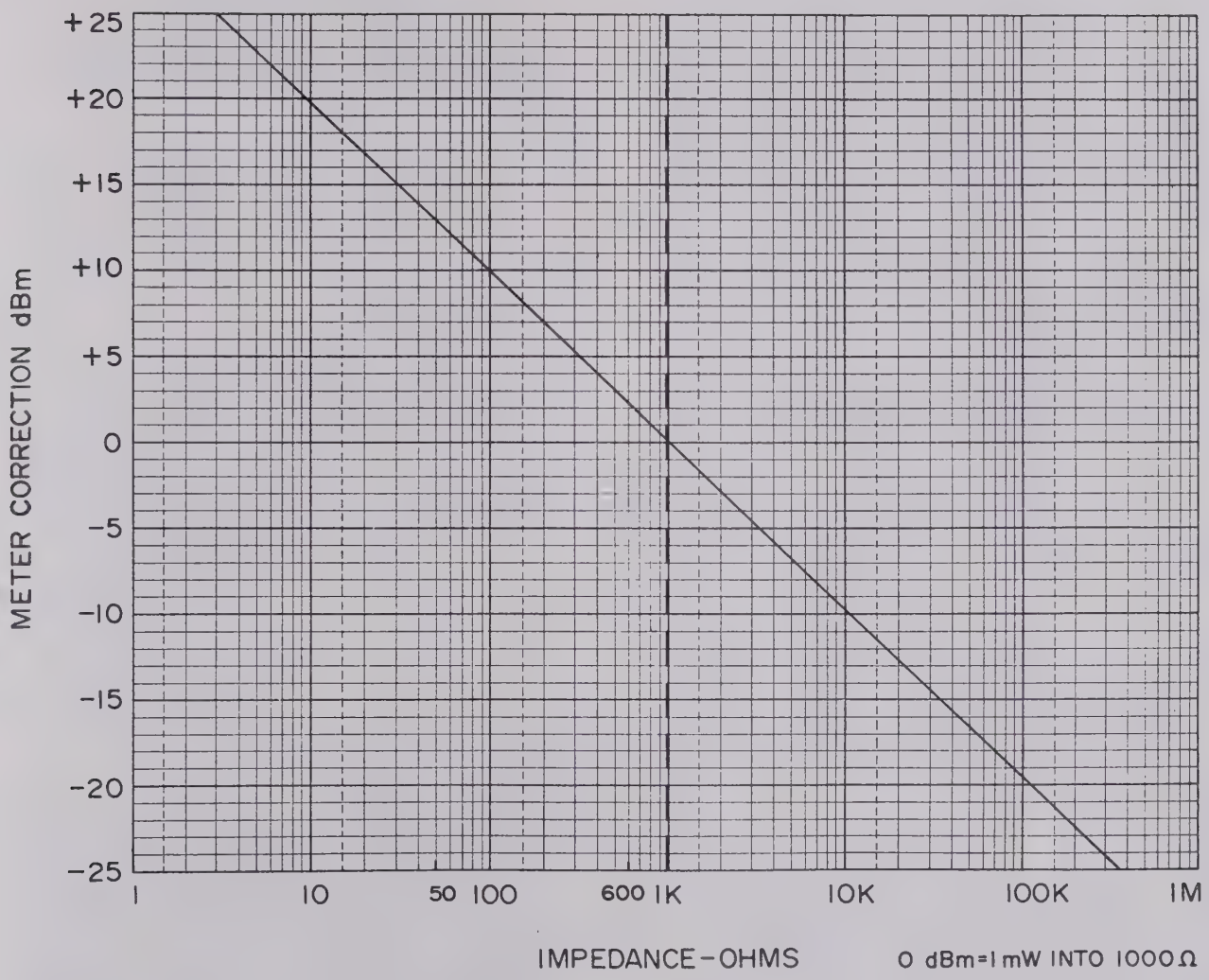


Figure 7–4. Impedance Correction Graph

zero mark. The DMM should be at 45 degrees or in its normal operating position when making this mechanical adjustment.

b. Push the DMM pushbutton switches S1 to ON, S2 to DC, S3 to V, and S8 to 1.

c. Connect a dc voltage source to the V-Ω and COMMON connectors. Apply approximately +1 volt.

d. Adjust A3R3, the meter zero adjust control, for minimum reading on the meter. Then change the polarity of the dc input voltage to −1 volt and again adjust A3R3 for minimum reading. Continue to switch the polarity of the input signal until the meter is fully balanced by A3R3 and reads the same for positive or negative input signals of equal voltage.

e. Remove the input signal and short the input connectors. The meter pointer should be at the zero mark of the upper meter scale within ±5 pointer widths on the 100 mV (S7) and 1 volt (S8) ranges.

f. Remove the short and connect a dc voltage calibrator to the V−Ω and COMMON input connectors of the voltmeter.

g. Apply a +1.950-volt input signal.

h. Adjust A3R7, the meter calibration adjustment control, until the meter reads just short of the 2 mark on the upper meter scale.

i. Reduce the input to +1.000 volt. The meter should read between 0.9 and 1.1; otherwise, compromise the adjustment of A3R7 until the best full-scale (2) and full-range (1) accuracy is obtained.

7–40. Schematic. A schematic diagram of the meter drive circuit is shown in Figure 7–5.

7–41. Parts List.

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
C 1	07095891A	CCD 100 NF 12 V M 20%	90201	RMC TYP M-12-0.1
C 2	07095892A	CCD 100 NF 12 V M 20%	90201	RMC TYP M-12-0.1
C 3	07095890A	CCD 100 NF 12 V M 20%	90201	RMC TYP M-12-0.1
C 4	07103390A	CRM 100.0NF 100.0 V +-10%	80031	MEPCO C280MCH/A100K
C 5	07095890A	CCD 100 NF 12 V M 20%	90201	RMC TYP M-12-0.1
CR 1	05079200A	DGP 1N4148 75 10M	07263	FCH SI 0035
CR 2	05079200A	DGP 1N4148 75 10M	07263	FCH SI 0035
CR 3	05079200A	DGP 1N4148 75 10M	07263	FCH SI 0035
CR 4	05079200A	DGP 1N4148 75 10M	07263	FCH SI 0035
CR 5	05079200A	DGP 1N4148 75 10M	07263	FCH SI 0035
CR 6	05079200A	DGP 1N4148 75 10M	07263	FCH SI 0035
M 1	18100341F	MTR 302RA-20 500UA S-P-SCHLE	50423	BLI IMPACT
Q 1	10100580A	TRQ 40673 MOSFET 20 MTO-72	86684	RCA .350 400M 12K
Q 2	10094730A	TRQ 2N3906 PNP 1 40 PTO-92	04713	MOT 1 200M 60
R 1	12125010A	RFF 100.0 K 500 MW F+-1%	16299	CGW RN60D 1003 F
R 2	12125000A	RFF 100.0 K 500 MW F+-1%	16299	CGW RN60D 1003 F
R 3	09100089A	RVC 10.0 K 0.5 WK +-10%	73138	HEL TYP 72PM
R 4	12125010A	RFF 100.0 K 500 MW F+-1%	16299	CGW RN60D 1003 F
R 5	12125680A	RFF 511.0 K 500 MW F+-1%	16299	CGW RN60D 5113 F
R 6	12126000A	RFF 1.00M 500 MW F+-1%	16299	CGW RN60D 1004 F
R 7	09100090A	RVC 1.0 K 0.5 WK +-10%	73138	HEL TYP 72PM
R 8	12123040A	RFF 1.10K 500 MW F+-1%	16299	CGW RN60D 1101 F
U 1	24101400A	ICP CA3140T OP AMP FET TO-8	86684	RCA CA31407
U 2	24101400A	ICP CA3140T OP AMP FET TO-8	86684	RCA CA31407

7–42. 10-AMPERE CURRENT RANGE, OPTION 21.

7–43. General. The 10-ampere current range option extends the current measuring capability of the 3028A to 20 amperes for both ac and dc rms current. Continuous measurements may be made to 10 amperes. Currents to 15 amperes are limited to 1½ minutes and a duty cycle of 50%. Currents to 20 amperes are limited to 1 minute and a duty cycle of 25%. The standard performance characteristics and specifications of the 3028A are not altered with Option 21 installed.

7–44. DC Specifications.

Ranges: ±10.00 amperes
1.5-minute operation to ±15 amperes
1-minute operation to ±20 amperes

Accuracy (15° to 35° C): ±(0.5% of reading + 1 LSD)

Voltage Burden: 0.5 V maximum to 10 A

Maximum Input: ±20 amperes

Operating Time: Continuous to ±10 amperes
1.5 minutes to ±15 amperes (50% duty cycle)
1 minute to ±20 amperes (25% duty cycle)

Response Time: 500 ms

7–45. AC Specifications.

Ranges: 10 amperes and 100% overrange to 20 amperes
1.5-minute operation to 15 amperes
1-minute operation to 20 amperes

Accuracy (+15°C to +35°C): 15 Hz to 10 kHz (sine wave) ±(2% of reading + 3 LSD)
45 Hz to 3 kHz (sine wave) ±(1% of reading + 2 LSD)
For distorted waveforms having less than 10% total harmonic distortion with no single harmonic greater than 5%, add ±(1.5% + 2 LSD) to the sine wave accuracy specified from 15

Voltage Burden: 0.5 V to 10 A for sine waves

Maximum Input: 20 A

Operating Time: Continuous to 10 A
1.5 minutes to 15 A (50% duty cycle)
1 minute to 20 A (25% duty cycle)

Response Time: 3 seconds maximum

7–46. Operation.

a. Push the DMM pushbutton switches S1 to ON, S2 to AC or DC as required, S4 to mA, and S9 to 10m.

b. Connect the input current leads to tight-fitting, clean, banana plugs which are connected to the 10-ampere range banana jacks on the front panel. Observe polarity for dc current measurements by connecting negative lead to LO connector. Always use the LO connector for the LO side of ac current inputs.

CAUTION

Do not exceed 20 amperes and the duty factors specified. Always set all switches before connecting signal to the 10-ampere input.

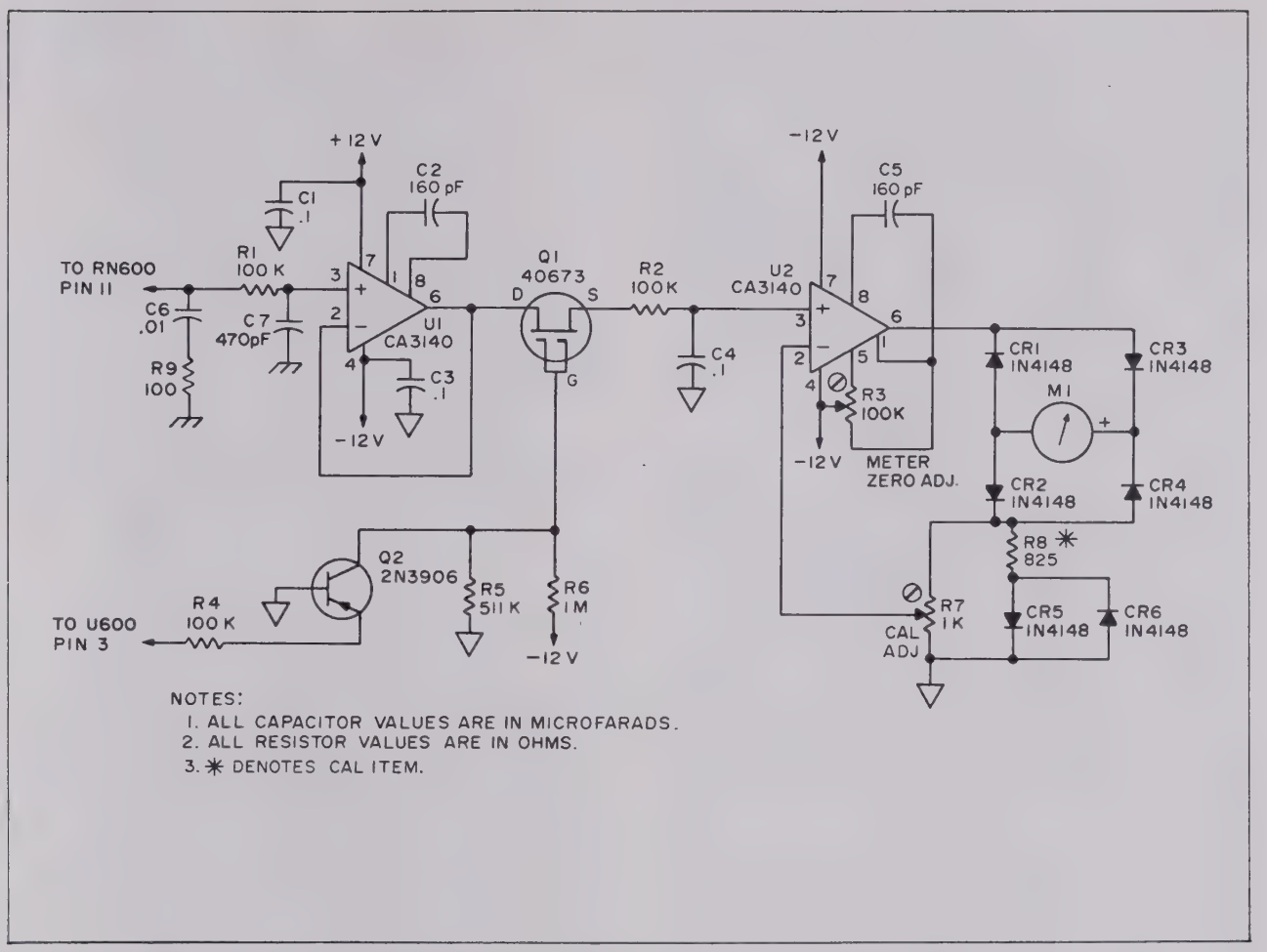


Figure 7–5. Option 20, Analog Meter Drive Circuit, Schematic Diagram.

7–47. Theory of Operation. A schematic diagram of the 10-ampere current range option is shown in Figure 7–6. A 0.01-ohm resistor is inserted into the low-end sensing return of the 0.1-ohm shunt resistor of RN200. The 0.01-ohm resistor is also a four-terminal network and is connected directly to its own input connector to avoid additional range switching. Proper positioning of the decimal point is performed by depressing the 10m range pushbutton S9.

7–48. Parts List.

R1200	Resistor, 0.01 ohm, four-terminal	P/N 1212955
--	Window	P/N 47100341

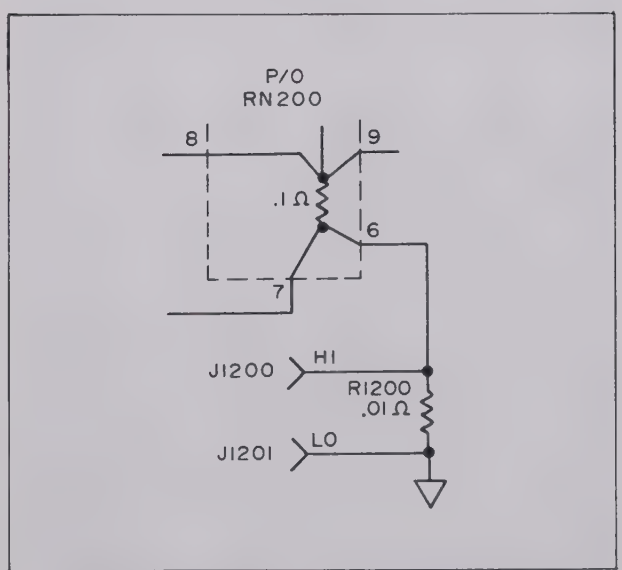


Figure 7–6. Option 21, 10-Ampere Current Range, Schematic Diagram.

7–49. TRANSIENT OVERVOLTAGE PROTECTION, OPTION 25.

7–50. General. Option 25 equips the 3028A with additional ac power line filtering and line transient surge protection to ensure optimum accuracy and maintenance-free use when the instrument is operated from ac power lines which

have high-transient voltage surges. This option is recommended when the 3028A is operated in high-altitude areas or in industrial environments where pumps, elevators, X-ray machines, spark gaps, magnetic activators, and other high-power equipment may cause voltage surges on the power line. In addition, Option 25 provides extra signal input overvoltage protection by the addition of two catch diodes in the input of the dc to digital converter. Should transient input signal overvoltage protection to 6 kV be required, contact the factory for optional modification 25H.

7–51. Specifications. None of the specifications and operating characteristics of the basic 3028A are changed with the addition of Option 25.

7–52. Installation. Transient overvoltage protection Option 25 is easily installed in the field. Remove the covers of the instrument (refer to paragraph 5–33). Remove the main printed wiring assembly and solder in diodes CR601 and CR602. Add the two capacitors C902 and C903 from the HI and LO side of the ac power input receptacle J50 to its earth ground pin. Make the capacitor leads as short as possible. Add the metal oxide varistor (MOV) surge suppressor RV900 across one primary of power transformer T900. This is readily done in the 120-volt connection by soldering RV900 from the LO pin of power receptacle J50 to the LO side of the fuse post holding F50. When Option 06 is installed and the 100-volt or 120-volt mode is selected also solder RV900 to the pins of J50 and F50.

For 220-volt and 240-volt operation, also solder RV901 from LO of J50 to the floating junction of the primaries making certain that the joint is well-insulated. After installing all parts, reassemble the printed circuit board and panels to the bottom cover. Perform the tests of the Performance Assurance Tests of paragraph 5–7 and give special attention to the adjustment of R605, the input offset adjustment control. Replace the cover and attaching hardware.

7–53. Parts List and Schematics. See Figure 7–7 for the circuit diagram. The schematic diagram, Figure 6–2 shows the locations of CR601, CR602, R903, and R904.

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
C 902	07025430A	CCD 1.5NF 3 KV M -20+80%	72982	ERIE 878 HI-K DISC Y5V
C 903	07025430A	CCD 1.5NF 3 KV M -20+80%	72982	ERIE 878 HI-K DISC Y5V
CR 601	05004680A	DGP FD300 150 375M .4	07263	FCH SI D07
CR 602	05004680A	DGP FD300 150 375M .4	07263	FCH SI D07
R 903	12179350A	RFC 47.0 M 1.0 W K+-10%	01121	A-B GB
R 904	12010040A	RFC 3.9 M 500.0MW J+- 5%	01121	A-B TYP EB

7–54. DC HIGH VOLTAGE PROBE MODEL 10800B.

7–55. General. The Ballantine Model 10800B DC High Voltage Probe, shown in Figure 7–8, is used to provide the instrument with a dc voltage capability to ±40,000 volts. The probe has a division ratio of 1000:1 and features a ±5% adjustment range for precise calibration at any voltage input. For additional information, refer to paragraph 3–83.

7–56. Specifications.

Voltage Range: ±1 kV to ±40 kV

Input Resistance: 1000 megohms

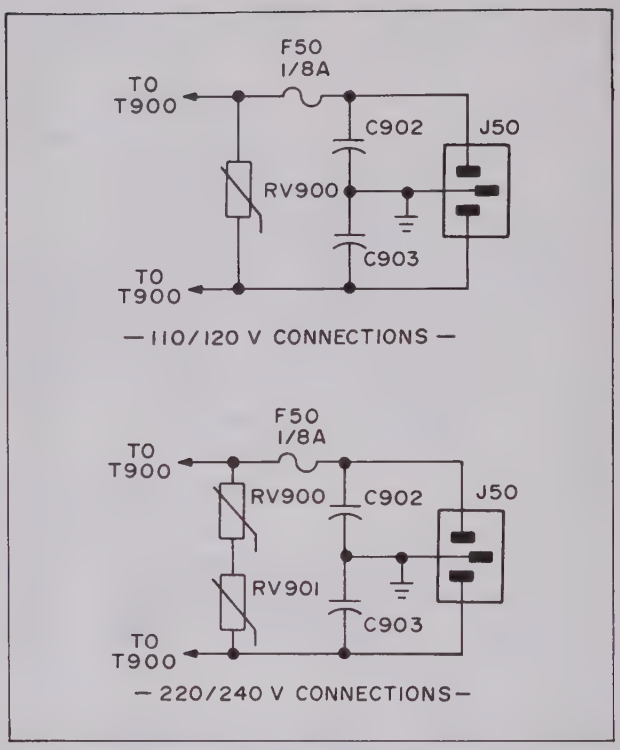


Figure 7–7. Option 25, Transient Overvoltage Protection, Schematic Diagram.

Figure 7–8. Model 10800B DC High Voltage Probe.

Division Ratio: 1000:1

Accuracy: ±1% referenced to calibration point
Voltage Coefficient:
2 ppm per volt, 1 to 10 kV (2%)
3 ppm per volt, 10 to 20 kV (3%)
5 ppm per volt, 20 to 40 kV (4%)

Maximum Input: ±40 kV peak

7–57. Operating Precautions. Before using the 10800B probe, connect a 3.3 MΩ, 1/2 W resistor (P/N 12129340A) from the neutral terminal of J50, the ac power receptacle, to earth ground, and a 47 MΩ, 1 W resistor (P/N 12129350A) from the instrument COMMON to earth ground (see Figure 7–8). These resistors will minimize shock hazard and equipment damage should the probe ground lead be disconnected accidentally. Also, with this modification, the dc common mode rejection will decrease to 90 dB.

WARNING

BEFORE CONNECTING THE HV PROBE, CONNECT THE GROUND-LEAD CLIP OF THE PROBE SECURELY TO THE GROUND (LO) OF THE CIRCUIT UNDER TEST. FAILURE TO OBSERVE THIS PRECAUTION WILL APPLY FULL HIGH VOLTAGE TO THE INSTRUMENT WHICH MAY CAUSE PERSONNEL SHOCK AND INSTRUMENT DAMAGE. THE GROUND-LEAD VOLTAGE MUST NOT EXCEED ±1200 VOLTS PEAK TO THE POWERLINE EARTH GROUND. HANDLE THE PROBE ONLY AT ITS BLACK HANDLE AND AVOID CONTACT WITH THE FLASH GUARD AND TIP AREA.

7–58. Operating Procedure.

a. Push the DMM pushbutton switches S1 to ON, S2 to DC, and S3 to V.

b. Select the DMM 1 range for operation to ±2 kV, the 10 range for operation to ±20 kV, or the 100 range for operation to ±40 kV. The display will read directly in kV.

c. Plug the termination of the 10800B probe into the V–Ω and COMMON connectors of the instrument, making sure that the red-marked banana plug of the termination mates with the V–Ω connector of the instrument.

d. Connect the ground-lead clip of the probe to the ground (LO) of the circuit under test.

e. Connect the probe tip to the circuit under test.

f. Turn the equipment on to apply the signal and read the instrument display.

7–59. Calibration.

a. Push the DMM pushbutton switches S1 to ON, S2 to DC, S3 to V, and S8 to 1.

b. Plug the 10800B probe termination into the V–Ω and COMMON connectors of the instrument, making sure that the red-marked banana plug of the termination mates with the V–Ω connector of the instrument.

c. Remove the four screws from the cover of the probe termination box and remove the cover to gain access to the potentiometer, R2.

d. Connect the ground-lead clip of the probe to the ground of a Fluke Model 332B DC Voltage Standard.

e. Connect the probe tip to the HI output of the Model 332B.

f. Apply ±1000.00 volts.

g. Use an insulated screwdriver and adjust R2 for a DMM display of .999 to 1001.

Note

Calibration may be performed at any voltage to 40 kV using other voltage standards and DMM ranges.

h. Replace the cover of the probe termination box and secure it with the four screws.

7–60. Schematic Diagram. A schematic diagram of the Model 10800B DC High Voltage Probe is shown in Figure 7–9.

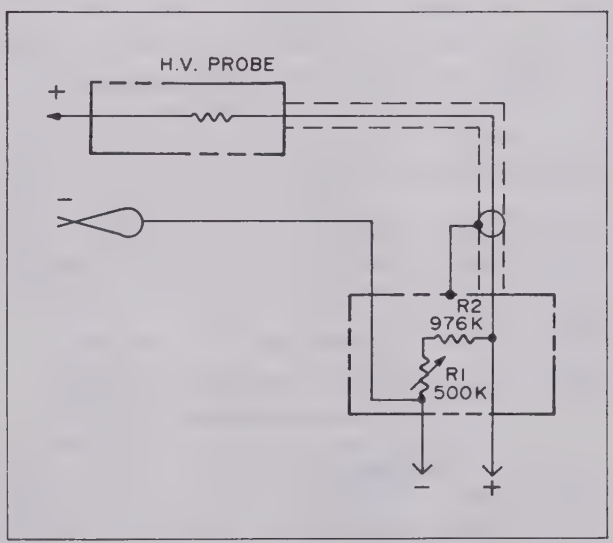


Figure 7–9. Model 10800B DC High Voltage Probe, Schematic Diagram.

7–61. Parts List.

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
R 1	09101640A	RVF 500.0 K 250 MW K CERMET	73138	HELIPOT 72XW VERT MT
R 2	12125950A	RFF 976.0 K 500 MW F+-1%	16299	CGW RN60D9763F
---	55100570A	PROBE BODY AND RESISTOR ASSY	50423	
---	79071410A	CBL 20-1 CONDUCTOR PLASTIC	92194	ALPHA NO. 1706
---	79045230A	WIRE, TEST LEAD, BLK	50423	
---	49044360A	ALLIGATOR CLIP	76545	MUELLER NO. 60

7–62. AC HIGH VOLTAGE PROBE MODEL 1301B.

7–63. General. The Ballantine Model 1301B AC High Voltage Probe, shown in Figure 7–10, is used to extend the ac rms voltage range of the instrument to 10 kV rms (14 kV peak). The probe has a capacitive division ratio of 10,000:1 (80 dB) and features a ±5% adjustment range for precise calibration at any voltage amplitude and frequency input. The 1301B is not a detector probe and therefore retains the rms response of the 3028A. Although the probe is usable beyond 6 MHz, its usefulness with the 3028A is limited to the specifications of the 3028A.

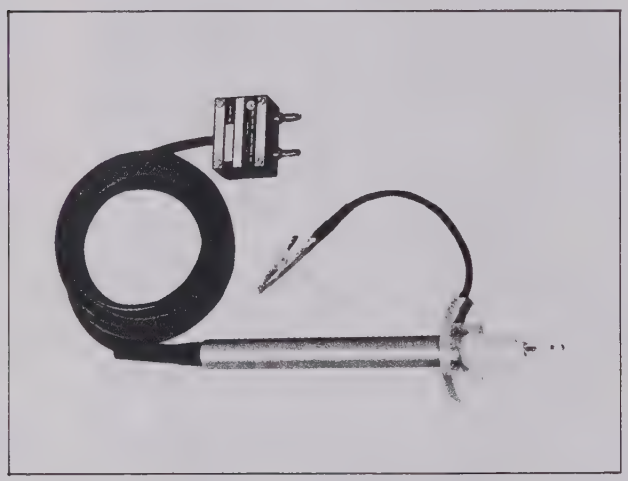


Figure 7–10. Model 1301B AC High Voltage Probe.

7–64. Specifications (with 3028A).

Voltage Range: <1 kV to 10 kV rms (14 kV peak)

Input Impedance: <10 pF in parallel with 1000 megohms

Division Ratio: 10,000:1 (80 dB)

Maximum Input: 10 kV rms sinusoidal; 14 kV peak

Accuracy: Adjustable ±1% to any reference condition within the specification
All accuracies are additive to the accuracies of the 3028A
45 Hz to 10 kHz ±1%
40 Hz to 110 kHz ±2%

7–65. Operating Precautions. Before using the 1301B probe, connect a 3.3 MΩ, 1/2 W resistor (P/N 12129340A) from the neutral terminal of J50, the ac power receptacle, to earth ground, and a 47 MΩ, 1 W resistor (P/N 12129350A) from the instrument COMMON to earth ground (see Figure 7–11). These resistors will minimize shock hazard and equipment damage should the probe ground lead be disconnected accidentally. Also, with this modification, the dc common mode rejection will decrease to 90 dB.

WARNING

BEFORE CONNECTING THE HV PROBE, CONNECT THE GROUND-LEAD CLIP OF THE PROBE SECURELY TO THE GROUND (LO) OF THE CIRCUIT UNDER TEST. FAILURE TO OBSERVE THIS PRECAUTION WILL APPLY FULL HIGH VOLTAGE TO THE INSTRUMENT WHICH MAY CAUSE PERSONNEL SHOCK AND INSTRUMENT DAMAGE. THE GROUND-LEAD VOLTAGE MUST NOT EXCEED ±1200 VOLTS PEAK TO THE POWERLINE EARTH GROUND. HANDLE THE PROBE ONLY AT ITS BLACK HANDLE AND AVOID CONTACT WITH THE FLASH GUARD AND TIP AREA.

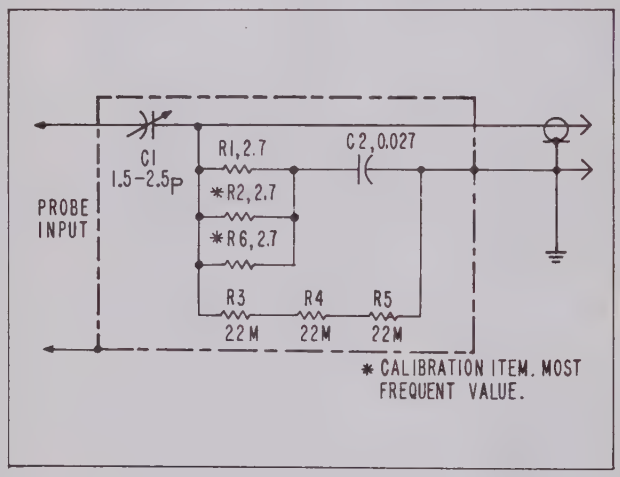


Figure 7–11. Model 1301B AC High Voltage Probe, Schematic Diagram.

7–66. Operating Procedure.

a. Push the DMM pushbutton switches S1 to ON, S2 to AC, and S3 to V.

b. Select the DMM 100 mV range for operation to 2 kV and the 1 range for operation to 10 kV. The display will read directly in kV.

c. Plug the termination of the 1301B probe into the V–Ω and COMMON connectors of the instrument, making sure that the red-marked banana plug of the termination mates with the V–Ω connector of the instrument.

d. Connect the ground-lead clip of the probe to the ground (LO) of the circuit under test.

e. Connect the probe tip to the circuit under test.

f. Turn the equipment on to apply the signal and read the instrument display.

7–67. Calibration.

a. Push the DMM pushbutton switches S1 to ON, S2 to AC, S3 to V, and S7 to 100 mV.

b. Plug the 1301B probe termination into the V–Ω and COMMON connectors of the instrument, making sure that the red-marked banana plug of the termination mates with the V–Ω connector of the instrument.

c. Unscrew the tip of the 1301 B probe to provide access to the calibration adjustment screw.

d. Connect the ground-lead clip of the probe to the ground of an ac voltage calibrator.

e. Connect the probe tip to the ac calibrator and apply 1 kV at 1 kHz.

f. Adjust the probe calibration screw with an insulated screwdriver until the DMM display reads .997 to 1.003.

g. Reinstall the probe tip and recheck the calibration.

7–68. Schematic Diagram. A schematic diagram of the Model 1301B AC High Voltage Probe is shown in Figure 7–11.

7–69. Parts List.

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
C 1	07081060A	CSM 27 NF 100 V J+-5%	92741	GOODALL TYPE 820UB
R 1	12012240A	RFC 2.7 250 MW K+-10%	01121	A-B TYPE CB
R 2	12012240A	RFC 2.7 250 MW K+-10%	01121	A-B TYPE CB
R 3	12012250A	RFC 22.0 M 250 MW K+-10%	01121	A-B TYPE CB
R 4	12012250A	RFC 22.0 M 250 MW K+-10%	01121	A-B TYPE CB
R 5	12012250A	RFC 22.0 M 250 MW K+-10%	01121	A-B TYPE CB
R 6	12012240A	RFC 2.7 250 MW K+-10%	01121	A-B TYPE CB
---	89054691A	GROUND LEAD ASSY	50423	
---	80070000A	SILICONE SEALING COMPND	71984	DOW CORNING NO. 5

7–70. RF DETECTOR PROBE MODEL 10850B.

7–71. General. The Ballantine Model 10850B RF Detector Probe, shown in Figure 7–12, is a peak detector probe calibrated in rms voltage. It uses semiconductor diodes and provides measurement capability beyond 700 MHz for sinusoidal signals. The maximum signal is 30 volts peak-to-peak and a blocking capacitor will hold off dc to a maximum of ±200 volts.

7–72. Specifications.

Frequency Range: <50 kHz to >700 MHz

AC to DC Transfer Accuracy (20°C to 30°C): Calibrated to ±1% at any point from 100 kHz to 200 kHz. Response ±0.5 dB from 100 kHz to 200 MHz; ±1 dB to 270 MHz; ±3 dB to 470 MHz

AM Detector: 50 Hz to 20 kHz

Maximum Input Voltage: AC, 30 volts; dc, ±200 volts maximum

Operating Voltage: Usable from 10 mV to 30 V; linear range, 250 mV to 10 V rms

Input Impedance: ≅3 pF shunted by ≅2 MΩ

Response: Peak responding from 250 mV to 30 V

Cable Length: 150 cm (5 ft)

Accessories: Ground lead, 50 Ω BNC adapter sleeve, retractile hook tip

7–73. Operation. The probe is supplied with an integral straight tip. It may be used with its ground lead connection to 100 MHz. Additionally, a retractile hook-tip is provided for convenience. For optimum accuracy above 10 MHz, the coaxial BNC adapter sleeve should be used. No ground lead is required when using the BNC adapter. The adapter is slipped onto the probe barrel and fits into any BNC female connector. The probe should always be used in a terminated system. The Ballantine Model 12630A 50-ohm BNC feed-thru termination is recommended.

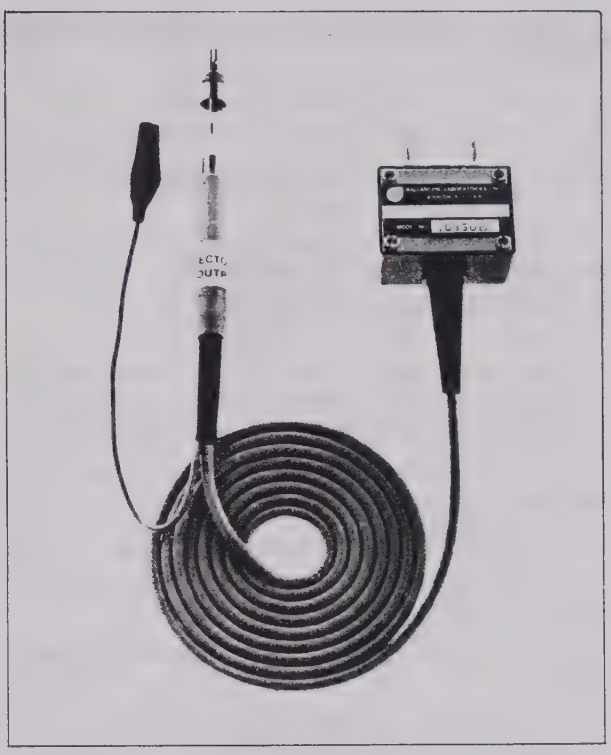


Figure 7–12. Model 10850B RF Detector Probe.

Maximum input voltage to the probe is 30 V rms or ±200 V dc. The 30-volt ac level may be additive and combined with the 200-volt dc limit.

CAUTION

DC input level changes greater than ±200 volts will damage the probe.

Take care to avoid ground current and common mode voltage measurement errors. Use battery off-line operation and/or check the effects of earth grounding the COMMON connector of the DMM.

7–74. Voltage Measurement of CW or FM Sine Wave Signals.

a. Connect the 10850A probe termination to the V–Ω and COMMON inputs of the DMM. Make sure the red-marked (HI) banana plug is connected to the V–Ω connector.

b. Attach the required probe tip, BNC adapter, and termination. Connect the probe to the circuit point to be measured.

c. Push the DMM pushbutton switches S1 to ON, S2 to DC, and S3 to V.

d. Select the desired voltage range: 100m, 1, or 10.

e. Note the display, which reads in volts rms.

7–75. Demodulation Measurement of AM Signal On High-frequency Carrier.

a. Connect the 10850A probe termination to the V–Ω and COMMON inputs of the DMM. Make sure the red-marked (HI) banana plug is connected to the V–Ω connector.

b. Attach the required probe tip, BNC adapter, and termination. Connect the probe to the circuit point to be measured.

c. Push the DMM pushbutton switches S1 to ON, S2 to AC, and S3 to V.

d. Select the desired range: 100m, 1, or 10.

e. Make sure the AM frequency is within the range of 50 Hz to 20 kHz and that the amplitude is stable.

f. The digital display will show the rms voltage of the carrier.

7–76. Calibration. The Model 10850A RF Probe is normally calibrated at 100 kHz. An ac voltage calibrator, such as the Hewlett-Packard Model 745, may be used to set the calibration with the trim potentiometer provided in the probe termination box. No high-frequency calibration is required. Proceed as follows:

a. Connect the 10850B probe to the V–Ω and COMMON inputs of the instrument.

b. Remove the four screws and cover from the probe termination.

c. Connect the 10850B probe to an ac voltage calibrator, such as the Hewlett-Packard Model 745. Set the calibrator output to 1 volt rms at 100 kHz.

d. Push the DMM pushbutton switches S1 to ON, S2 to AC, S3 to V, and S8 to 1.

e. Adjust the trim potentiometer with an insulated screwdriver until the instrument display reads .998 to 1.002.

f. If desired, check the probe at 250 mV rms, 10 V rms, and 25 V rms inputs.

g. Replace the probe termination cover and the four screws.

7–77. High-frequency Certification. Should high-frequency certification be required, use a Ballantine Model 440 Micropotentiometer with a 220-ohm coaxial resistor to drive a General Radio 874-K Line Stretcher and a GR 874 BNC female adapter with a 50-ohm feed-thru termination, Ballantine 12630A. Connect the 10850B BNC adapter sleeve and fit the probe into the female BNC of the 12630A. Then calibrate the micropotentiometer with a 100-kHz signal input. Increase the input ac signal until the probe output is .500 volt as read on the DMM. Monitor the micropotentiometer thermoelement output with a dc millivoltmeter, such as the 3028A which has a 100 μV resolution. Then apply an rf signal generator to the micropotentiometer in place of the 100-kHz input. Increase the rf input until the micropotentiometer thermoelement output voltage is identical to that noted with the 100-kHz input. Then slide the GR 874-K Line Stretcher until the average of the maximum and minimum signals are noted on the 3028A which reads the 10850B probe output. This reading is the response of the 10850B probe at this frequency referenced to 100 kHz.

7–78. Schematic Diagram. A schematic diagram of the Model 10850B RF Detector Probe is shown in Figure 7–13.

7–79. Parts List. The probe is sealed and the entire probe must be replaced when the demodulator probe head is faulty. Replaceable parts are included in the following parts list.

SCHEMATIC REF		BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
C	1	07025920A	CMB 1.0 NF 1.0 KV K+-10%	84171	ARCO TYPE CCD-102
R	1	12126080A	RFF 1.21 M 500 MW F+-1%	16299	CGW RN65D1214F
R	2	09101200A	RVP 100.0 K 250 MW K CERMET	73138	HELIPOT 72XW VERT MT
---		85100580A	PROBE AND CABLE ASSY	50423	

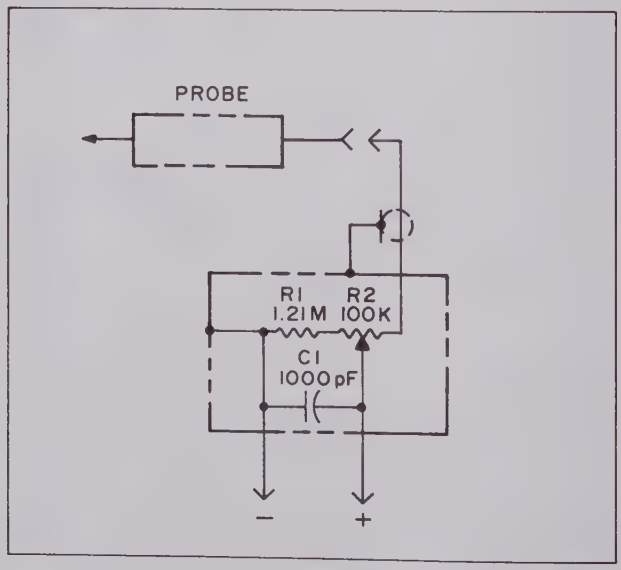


Figure 7–13. Model 10850B RF Detector Probe, Schematic Diagram.

Ballantine Laboratories, Inc.

ADDENDUM

TO INSTRUCTION MANUAL:

MODEL No. 3028A

Serial No. Prefix 030
and above.

Instruments with Serial Number Prefix 030 and above differ from earlier instruments in several areas:

1. The ohmmeter circuit polarity is reversed so that the COMMON connector is negative and the V-Ω connector is positive. The LO Ω range is now 200 mV full scale and HI Ω is 2 V full scale.

2. The 100 mV (S7) and 1 V (S9) ranges of the analog to digital converter are selected by a FET switch controlled by S7 and S9.

3. A larger, higher brightness, LED display is used incorporating new LED and changed driver circuitry.

4. The AC to DC rms responding converter is further improved by dc coupling the peak detector thru the average detector.

5. Option 24 which provides 10 mV and 10 ohm high sensitivity ranges is deleted. These performance features have been replaced by the new Model 3028B.

Page 1-1

Paragraph 1-2 - Change: 180 mV to 200 mV
1.8 V to 2 V
0.4 inch to 0.43 inch

Paragraph 1-3 - Change: (≤ 180 mV) to (≤ 200 mV)
(≤ 1.8 V) to (≤ 2 V)

Page 1-2

Paragraph: AC VOLTAGE. Maximum Input Voltage.

Change: 10^3 to 10^8 Volt Hertz

Paragraph RESISTANCE.

Change: FS Volts
180 mV to 200 mV (5 times)
1.8 V to 2 V (5 times)

ref:

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Model 3028A - Serial No. Prefix Code 030 and above.

Page 1-3

Paragraph: TEMPERATURE. Storage.

Change: 50° to 55°C

Paragraph: DISPLAY.

Change: 1.1 cm (0.4 inch) to 1.2 cm (0.43 inch)

Table 1-1. Accessories.

Add: Model 12628A 100:1 capacitive divider for 10856B
(Extends 10850B RF probe to 300 V.)

Page 1-4

Table 1-2 Options.

Delete: Option 22 - Temperature Probe Accessory
Option 23 - Temperature Probe Accessory
Option 24 - 10 mV dc Range with 10 μV resolution

Add: Option 24 - AC average responding.

Page 3-3

Table 3-2 Change: HIΩ (>1.8 V FS) to HIΩ (>2 V FS)

Change: LOΩ (≤ 180 mV FS) to LOΩ (≤ 200 mV FS)

Page 3-4

Paragraph 3-27c.

Change: Clamp at ±200 mV to clamp at ±600 mV.

Page 3-7

Paragraph 3-57

Change: 180 mV to 200 mV.

Paragraph 3-58

Change: 900 mV to 1 V

Change: 1.80 V to 2 V

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Model 3028A - Serial No. Prefix Code 030 and above.

Page 3-8

Figure 3-3

-DIODE-

Interchange: COMMON and V-Ω

-NPN TRANSISTOR-

Interchange: COMMON and V-Ω

-DNP TRANSISTOR-

Interchange: COMMON and V-Ω

Paragraph 3-71

Change: ...is positive in respect to the COMMON connector...to
...is negative with respect to the COMMON connector...

Page 3-9

Table 3-3

Change: COMMON (-) to V-Ω (-)

Change: V-Ω (+) to COMMON (+)

Paragraph 3-75

Change: 180 mV to 200 mV

Paragraph 3-76C

Change: 180 microamperes to 200 microamperes

Paragraph 3-79

Add: For measuring ac voltages above 30 V use Model 12628A 100:1 capacitive divider tip up to a maximum of 300 volts.

Page 4-2

Paragraph 4-16

Change: 1.8 V to 2 V

Paragraph 4-17

Change: ±10 V to ±12 V

7/77

Model 3028A - Serial No. Prefix Code 030 and above.

Page 4-2 (con't)

Paragraph 4-18

Delete in its entiretry.

Page 4-3

Paragraph 4-25

Delete in eighth sentence: "and is calibrated in rms of a sinewave."

Figure 4-4

Delete: C500, CR400 and R500. Connect + input of U500 to the junction of CR403 and R400.

Page 5-2

Table 5-4

Add: 180 mV 110 kHz 100m 170.7 to 189.3

Page 5-3

Paragraph 5-8

Add: Make all checks with COMMON input connector tied to earth ground at the lug on the rear panel.

Page 5-4

Table 5-7

Change: +11.3 to 11.8

Change: -11.3 to -11.8

Page 5-7

Paragraph 5-48

Delete the adjustment of R103. In the 3028A with serial number prefix 030, R102 is fixed at 90k 0.05%.

Page 5-14

8. AC Voltage Calibration Check

Add: 180 mV 110 kHz 100m 170.7 to 189.3

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3028A (SERIAL NO. PREFIX 030-)
PARTS LIST & CIRCUIT DIAGRAMS

The replacement parts listed are available from the vendors listed or from Ballantine Laboratories. Your local Ballantine Field Engineering Representative may also carry a stock of parts and can assist you. If pricing quotations are required for parts and or repairs your local representative will give the most rapid service or you may contact the Ballantine Factory directly.

When ordering replacement parts always give the following information:

a) Instrument Model number
b) Serial number
c) Ballantine Part number
d) Schematic Symbol number
e) Identification and description of the part

Ballantine will do its best to improve the instrument and make changes in style of components and replacement parts. Replacement parts may differ in appearance from those found in your instrument but are always equal or superior in performance. Where necessary minor mechanical modifications may be required in the replacement of the components.

Parts are generally available locally for most replacements. The parts list calls out the recommended vendors where applicable.

The instrument may substitute alternate components but the use of parts specified in this parts list is recommended. A part similar to the part initially installed at the factory may be used, i.e., a 5% composition resistor may be replaced with a similar part or a 5% film resistor or the preferred 1% metal film resistor. Use of the preferred component will always simplify calibration and speed repairs.

Any selected component is generally identified in this manual and may be replaced with a similarly valued part unless reselection is required due to replacement or change of its related part. The schematics and calibration procedures identify selected components and replacement procedures.

The Manufacturer Code is taken from Federal Supply Code Cataloging Handbooks H4-1, H4-2, and H4-3. Ballantine Code is 50423.

The following parts coding are used:

CVC	Capacitor, Variable, Ceramic
CCT	Capacitor, Ceramic, Tubular
CFP	Capacitor, Fixed, Plastic
CCD	Capacitor, Ceramic, Disc
CYF	Capacitor, Mylar, Foil
CMD	Capacitor, Mica, Dipped
CMM	Capacitor, Mica, Molded
CEA	Capacitor, Electrolytic, Aluminum
CET	Capacitor, Electrolytic, Tantalum
DGP	Diode, General Purpose
DZG	Diode, Zener, General Purpose
DRP	Diode, Bridge, Power
FLT	Filter
ICP	Integrated Circuit
TRQ	Transistor
RFF	Resistor, Fixed, Film
RFC	Resistor, Fixed, Composition
RVC	Resistor, Variable, Composition
RFW	Resistor, Fixed, Wirewound
SWC	Switch
LMP	Lamp
TRX	Transformer

Resistors may generally be replaced by Corning Electronics (CCW) type N-55, N-60 and C-32. Allen Bradley carbon composition resistors type EB may also be used but should generally be avoided (except for emergency replacements) in favor of the preferred part listed in this parts list.

3028A PARTS LIST (SERIAL NO. PREFIX 030-)

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
C 100	07103360A	CBM 47.0NF 1.6KV +-10%	80031	MEPCO C281/1600/A47K
C 101	07104351B	CTE 4.5PF 1.2KVJ	50423	
C 102	07103490A	CMD 560.0PF 500.0 V TCE 1%	84171	ARCO DM15ED560F03 ARCO
C 103	07103600A	CVC 10-60PF 350.0 V N750	50423	
C 105	07103540A	CMD 1.0NF 500.0V +-1%	84171	ARCO DM-19-E-D-1000-F-N-U
C 107	07103471A	CVF 1.2PF 1.2KVJ	50423	
C 108	07101030A	CMD 250.0PF 500V +-5%	84171	ELMENCO DM1525J
C 110	07103600A	CVC 10-60PF 350.0 V N750	50423	
C 300	07101370A	CMO 160 PF 500 VJ	72136	ELMENCO DM15FD161J03
C 301	07101370A	CMO 160. PF 500. VJ	72136	ELMENCO DM15FD161J03
C 401	07101980A	CCD 100.0NF 25.0 V NPO	56289	SPRAG C069A250M1042 OR EQ
C 403	07103410A	CBM 470.0NF 100.0 V +-10%	80031	MEPCO C280MCH/A470K
C 404	07101980A	CCD 100.0NF 25.0 V NPO	56289	SPRAG C069A250M1042 OR EQ
C 406	07102580A	CET 68.0UF 15.0 VK DIP TAN	56289	SPRAG 196D686X9015-LA3
C 407	07101790A	CET 22.0UF 15.0 VM	56289	SPRAGUE 196D226X0015KE3
C 408	07101790A	CET 22.0UF 15.0 VM	56289	SPRAGUE 196D226X0015KE3
C 409	07100040A	CMD 300.0PF 500.0V DM15	84171	ARCO DM-15-301J
C 410	07103410A	CBM 470.0NF 100.0 V +-10%	80031	MEPCO C280MCH/A470K
C 501	07103410A	CBM 470.0NF 100.0V +-10%	80031	MEPCO C280MCH/A470K
C 502	07101980A	CCD 100.0NF 25.0 V NPO	56289	SPRAG C069A250M1042 OR EQ
C 503	07101980A	CCD 100.0NF 25.0 V NPO	56289	SPRAG C069A250M1042 OR EQ
C 600	07103370A	CBM 68.0NF 630.0 V +-10%	80031	MEPCO C280MCG/A68K
C 601	07103380A	CBM 33.0NF 400.0 V +-10%	80031	MEPCO C280MCF/A33K
C 602	07103390A	CBM 100.0NF 100.0 V +-10%	80031	MEPCO C280MCH/A100K
C 603	07201350A	CMD 22.0PF 5%	84171	DM 15-220J
C 605	07103400A	CBM 22.0NF 400.0 V +-10%	80031	MEPCO C280MCF/A22K
C 610	07100530A	CET 10.0UF 35.0V M	56289	SPRAGUE 196D106X0035A3
C 700	07101790A	CET 22.0UF 15.0 VM	56289	SPRAGUE 196D226X0015KE3
C 701	07101790A	CET 22.0UF 15.0 VM	56289	SPRAGUE 196D226X0015KE3
C 703	07101980A	CCD 100.0NF 25.0 V NPO	56289	SPRAG C069A250M1042 OR E
C 800	07103380A	CBM 33.0NF 400.0 V +-10%	80031	MEPCO C280MCF/A33K
C 801	07103380A	CBM 33.0NF 400.0 V +-10%	80031	MEPCO C280MCF/A33K
C 802	07104390A	CEA 100UF 6.3V	--	CAPAR CRE 100UF/6.3V
C 803	07103060A	CEA 1000UF 16.0V	50423	
C 804	07103060A	CEA 1000UF 16.0V	50423	
C 805	07101980A	CCD 100.0NF 25.0 V NPO	56289	SPRAG C069A250M1042 OR EQ
C 806	07101980A	CCD 100.0NF 25.0 V NPO	56289	SPRAG C069A250M1042 OR EQ
C 807	07101980A	CCD 100.0NF 25.0 V NPO	56289	SPRAG C069A250M1042 OR EQ
C 808	07104390A	CEA 100.0UF 6.3 V		CAPAR CRE 100UF/6.3V
C 900	07104470A	CEA2200.0UF 16.0 V	50423	
CB 10	19100351E	CBK 2A BREAKER FAST LNG SHFT	50423	
CR 200	05100630A	DRP 1N5400 50 3A	04713	MOT SI
CR 201	05100630A	DRP 1N5400 50 3A	04713	MOT SI
CR 202	05100630A	DRP 1N5400 50 3A	04713	MOT SI
CR 203	05100630A	DRP 1N5400 50 3A	04713	MOT SI
CR 300	05100990A	DZG 1N5243A 13.0VJ .5W	04713	MOT 1N5243A 13V ZENER
CR 301	05100990A	DZG 1N5243A 13.0VJ .5W	04713	MOT 1N5243A 13V ZENER
CR 401	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
CR 402	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
CR 403	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
CR 500	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
CR 800	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
CR 801	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
CR 802	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
CR 803	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
CR 804	05079200A	DGP 1N4148 75 10M	07263	FCH SID035
CR 805	05079200A	DGP 1N4148 75 10M	07263	FCH SI D035
CR 900	05100060A	DGP W04M 400 1.5A	04713	GIC
DS 750	21100400A	IND 0.43 IN HI EFF.RED C.C	28480	HP 5082-7653 COMMON CAT.
DS 751	21100400A	IND 0.43 IN HI EFF.RED C.C	28480	HP 5082-7653 COMMON CAT.
DS 752	21100400A	IND 0.43 IN HI EFF.RED C.C	28480	HP 5082-7653 COMMON CAT.
DS 753	21100410A	IND 0.43 IN.HIEF.RED CC +-1	28480	HP 5082-7656 COMMON CAT.

3028A PARTS LIST (SERIAL NO. PREFIX 030-) — Continued

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
F 50	19100360A	FUS .125A NORMAL-BLO	75915	LITTELFUSE TYP3AG NORMBLO
J 1	31301260A	CON FLEXPRINT 20 PINS PC MT	26364	ANSLEY 609 2003
J 10	31101320A	BPS 10MM GREY	50423	
J 20	31101320A	BPS 10MM GREY	50423	
J 30	31101330A	BPS 10MM BLACK	50423	
J 50	31100000A	REC AC POWER	82389	SWITCHCRAFT
L 10	46100020A	FRB FER BD 4AMAT.047ID	02114	FERROX CUBE 56590 65/HA
L 20	46100020A	FRB FER BD 4AMAT.047ID	02114	FERROX CUBE 56590 65/HA
L 30	46100020A	FRB FER BD 4AMAT.047ID	02114	FERROX CUBE 56590 65/HA
Q 300	10094730A	TRQ 2N3906 PNP 1 40 PTO-92	04713	MOT 1 200M 60
Q 301	10094730A	TRQ 2N3906 PNP 1 40 PTO-92	04713	MOT 1 200M 60
Q 302	05100761B	DZG SPECIAL	50423	
Q 400	10101051A	TRQ 40673 SEL FOR LEAK	50423	
Q 401	10094730A	TRQ 2N3906 PNP 1 40 PTO-92	04713	MOT 1 200M 60
Q 600	10100990A	TRQ E507	17856	SILICONIX
Q 601	05100761B	DZG SPECIAL	50423	
Q 602	10100290A	TRQ 2N4400 NPN 1 40 PTO-92	04213	MOT 1 200M 20
Q 610	10101280A	TRQ E111 N J FET TO-106	17856	SILICONIX E111 RDS=300HM
Q 700	10100430A	TRQ 2N3904 NPN 1 40 PTO-92	04713	MOT 1 300M 40
Q 701	10094730A	TRQ 2N3906 PNP 1 40 PTO-92	04713	MOT 1 200M 60
Q 800	10100870A	TRQ 2N5193 PNP 1 40 P7703	04713	MOT 40 2M 10
Q 801	10100870A	TRQ 2N5193 PNP 1 40 P7703	04713	MOT 40 2M 10
R 100	12128670A	RFF 9.76M 2.0 W 1%	03888	PYROFILM PME 64T9 2.5KV
R 101	09100090A	RVC 250.0 K 0.5 WK +-10%	73138	HEL TYP 72PM
R 102	12129370A	RFW 90.0K 1.0W .05% NI	50423	
R 104	12128610A	RFW 10.0 K 7.0 W 0.05%	50423	
R 105	12010030A	RFC 5.1M 500.0MWJ+-5%	01121	A-B TYP EB
R 200	12128730A	RFC 560.0 K 500.0MW	01121	A-B TYPE E-B
R 201	12128730A	RFC 560.0 K 500.0MW	01121	A-B TYPE E-B
300	12123890A	RFF 8.45K 250.0MW FT- 1%	16299	CGW RN55D 8451 F
301	09100050A	RVF 1.00K 0.5 WK CERMET	73138	HELIPOT 72PM
R 302	12123000A	RFF 1.0 K 250.0MW FT- 1%	16299	CGW RN55D 1001 F
R 303	12123760A	RFF 6.19K 250.0MW FT- 1%	16299	CGW RN55D 6191 F
R 304	09100050A	RVF 1.00K 0.5 WK CERMET	73138	HELIPOT 72PM
R 305	12010480A	RFC 4.7 K 500.0MW J+- 5%	01121	A-B TYP EB
R 310	12010440A	RFC 10.0K 500.0MWJ+-5%	01121	A-B TYP EB
R 400	12128630A	RFC 150.0 K 2.0 W 5%	01121	A-B HB
R 401	12010570A	RFC 1.0 K 500.0MWJ +- 5%	01121	A-B TYP EB
R 402	12010480A	RFC 4.7 K 500.0MW J+- 5%	01121	A-B TYP EB
R 404	12010070A	RFC 2.0 M 500.0MW J+- 5%	01121	A-B TYP EB
R 405	12123280A	RFF 1.96K 250.0MW FT-1%	16299	CGW RN55D 1961F
R 406	12123280A	RFF 1.96K 250.0MW FT-1%	16299	CGW RN55D 1961F
R 408	12122920A	RFF 909.0 250.0MW FT- 1%	16299	CGW RN55D 9090 F
R 409	09100040A	RVF 100.0 0.5 W M	73138	HEL TYP 72PM
R 410	12123400A	RFF 2.61K 250.0MW FT-1%	16299	CGW RN55D 2611F
R 411	12089580A	RCF 240.0 K 500.0MW J+- 5%	01121	A-B TYP EB
R 501	12123280A	RFF 1.96K 250.0MW FT-1%	16299	CGW RN55D 1961F
R 502	12010720A	RFC 39.0 500.0MW J+- 5%	01121	A-B TYP EB
R 503	12080210A	RFC 1.2 M 250.0MW J+- 5%	01121	A-B TYP CB
R 504	12098260A	RFC 4.7 M 250.0MW J+- 5%	01121	A-B TYP CB
R 505	12010500A	RFC 3.9 K 500.0MW J+- 5%	01121	A-B TYP EB
R 506	09100030A	RVC 100.0 K 0.5 WK +-10%	73138	HEL TYP 72PM
R 600	12128620A	RFC 560.0 K 2.0 W 5%	01121	A-B HB
R 601	12128730A	RFC 560.0 K 500.0MW	01121	A-B TYPE E-B
R 602	12010810A	RFC 27.0 K 500.0MW J+- 5%	01121	A-B TYP EB
R 604	09101460A	RVF 25.0 K 500.0MW TRIMPOT	73138	HELIPOT 72PM
R 605	09101460A	RVF 25.0 K 500.0MW TRIMPOT	73138	HELIPOT 72PM
R 606	12011380A	RFC 1.8 500.0MW K+-10%	01121	A-B TYP EB
R 607	09100020A	RVC 5.0 K 0.5 WK +-10%	73138	HEL TYP 72PM
R 608	09100010A	RVC 500.0 0.5 W K	73138	HEL TYP 72PM
611	12124000A	RFF 10.0 K 250.0MW FT- 1%	16299	CGW RN55D 1002 F
612	12125000A	RFF 100.0 K 250.0MW FT- 1%	16299	CGW RN55D 1003 F

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
R 700	12010480A	RFC 4.7 K 500.0MW J+- 5%	01121	A-B TYP EB
R 701	12010480A	RFC 4.7 K 500.0MW J+- 5%	01121	A-B TYP EB
R 702	12010480A	RFC 4.7 K 500.0MW J+- 5%	01121	A-B TYP EB
R 703	12010680A	RFC 100.0 500.0MWJ +-5%	01121	A-B TYP EB
R 704	12010680A	RFC 100.0 500.0MWJ +-5%	01121	A-B TYP EB
R 705	12011120A	RFC 470.0 500.0MW J+- 5%	01121	A-B TYP EB
R 706	12010680A	RFC 100.0 500.0MWJ +-5%	01121	A-B TYP EB
R 710	12010680A	RFC 100.0 500.0MWJ +-5%	01121	A-B TYP EB
R 711	12010680A	RFC 100.0 500.0MWJ +-5%	01121	A-B TYP EB
R 712	12080110A	RFC 10.0 K 250.0MW J+- 5%	01121	A-B TYP CB
R 713	12010480A	RFC 4.7K 500.0MWJ +-5%	01121	A-B TYP EB
R 800	12010440A	RFC 10.0 K 500.0MW J+- 5%	01121	A-B TYP EB
R 801	09101070A	RVF 200.0 250.0MW K CER	73138	HEL TYPE 72PM-200
R 900	12124640A	RFF 46.4 K 250.0MW FT- 1%	16299	CGW RN55D 4642 F
R 901	12123720A	RFF 5.62K 250.0MW FT- 1%	16299	CGW RN55D 5621 F
RN 200	13100021A	RNW 3028A SHUNT RES,14DIP	50423	
RN 600	13100001B	RNF 8 RES 14DIP HI VALUE	50423	
RN 700	13100100A	RNF 100 500MW 8 RES DIP	32997	BOURNS 4116R-001-101
RN 800	13100011B	RNF 8 RES 14 DIP LO VALUE	50423	
S 1	25101381N	SWC 3028A RMS RANGE 6 PB	71590	BLI REV CENTRALAB
S 2	25101381N	SWC 3028A RMS RANGE 6 PB	71590	BLI REV CENTRALAB
S 3	25101381N	SWC 3028A RMS RANGE 6 PB	71590	BLI REV CENTRALAB
S 4	25101381N	SWC 3028A RMS RANGE 6 PB	71590	BLI REV CENTRALAB
S 5	25101381N	SWC 3028A RMS RANGE 6 PB	71590	BLI REV CENTRALAB
S 6	25101381N	SWC 3028A RMS RANGE 6 PB	71590	BLI REV CENTRALAB
S 7	25101391L	SWC 3028A RMS FUNCTION 6 PB	71590	CENTRALAB
S 8	25101391L	SWC 3028A RMS FUNCTION 6 PB	71590	CENTRALAB
S 9	25101391L	SWC 3028A RMS FUNCTION 6 PB	71590	CENTRALAB
S 10	25101391L	SWC 3028A RMS FUNCTION 6 PB	71590	CENTRALAB
S 11	25101391L	SWC 3028A RMS FUNCTION 6 PB	71590	CENTRALAB
S 12	25101391L	SWC 3028A RMS FUNCTION 6 PB	71590	CENTRALAB
T 800	20100291D	TRX 3028A DC/DC CONVERTER	50423	
T 900	20100311Q	TRX 3028A-39 POWER TRANS	50423	
U 300	24101400A	ICP CA3140T OP AMP FET-T08	86684	RCA CA3140T
U 400	24102130A	ICP LM318N FAST OP AMP	27014	NAT.SEMI DUAL IN LIN
U 500	24102140A	ICP CA3130S FET OP AMP TO-5	86684	RCA CA3130S TO-5 DU IN LN
U 600	24100931A	TCP DVM ANALOG 0.03%	17856	SILICONIX LD111 MODIFIED
U 700	24100941A	ICP DVM DIGITAL 3 1/2 DIGIT	17856	SILICONIX LD110 MODIFIED
U 701	24101880A	ICP 9667 7 DARLINGTON DRIVE	07263	FAIRCHILD 9667PC
U 702	24101860A	ICP 74C48 7 SEGMENT DRIVE		NATIONAL MM74C48N
U 900	24100010A	TCD UA7805	07263	FAIRCHILD

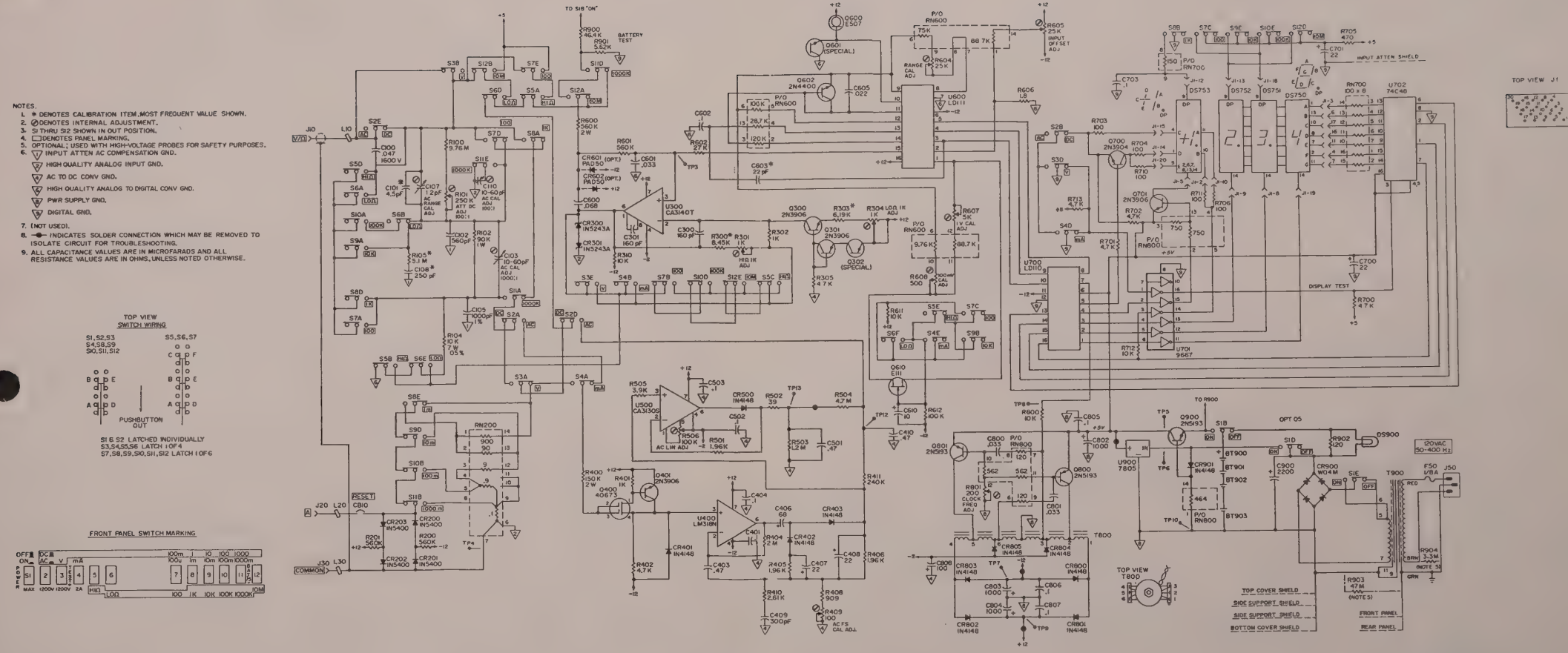

Figure 6-1. Model 3028A (Serial No. Prefix 030-), Schematic Diagram

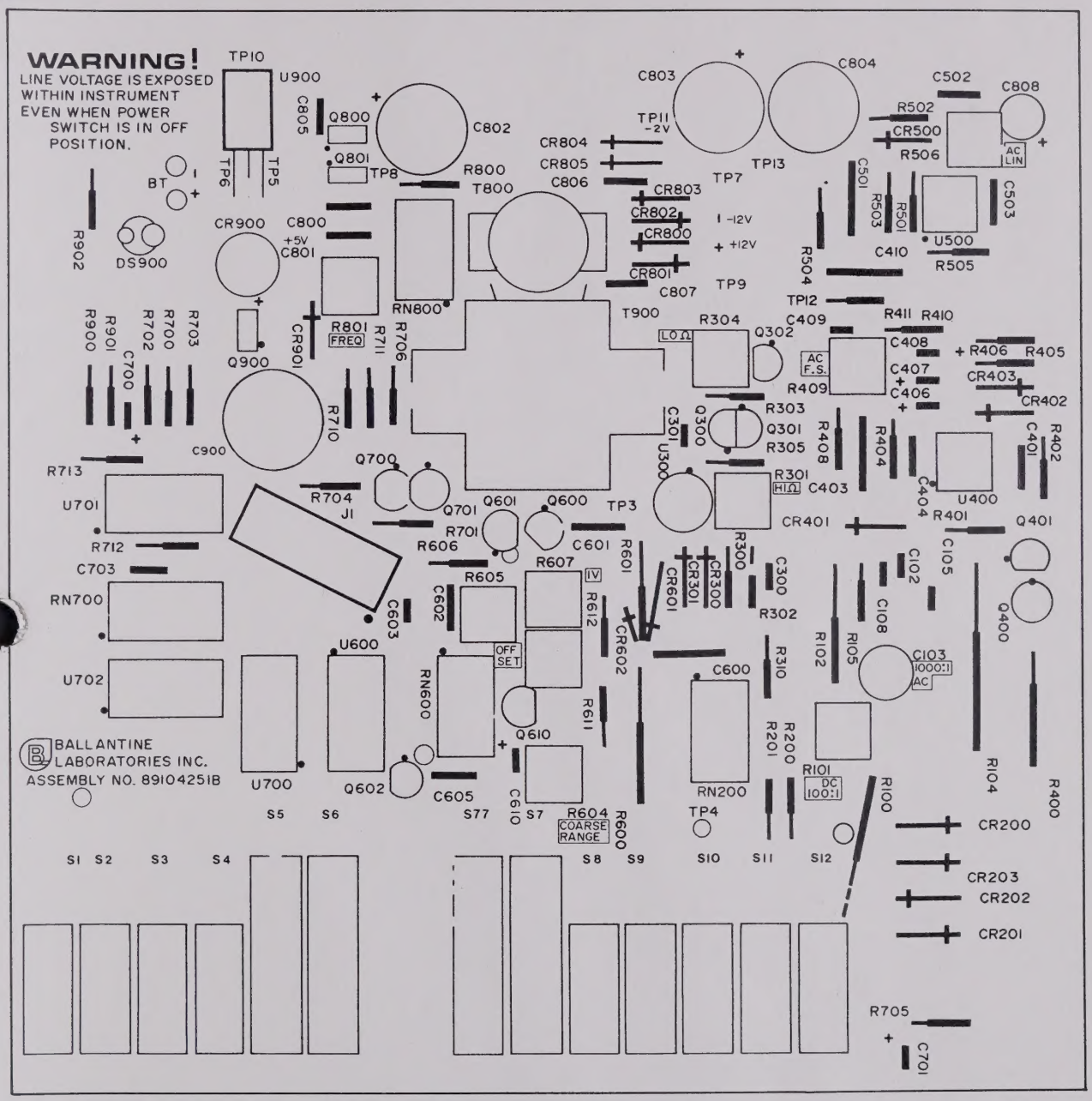

Figure 6–2. Model 3028A (Serial No. Prefix 030-), Parts Location Diagram

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